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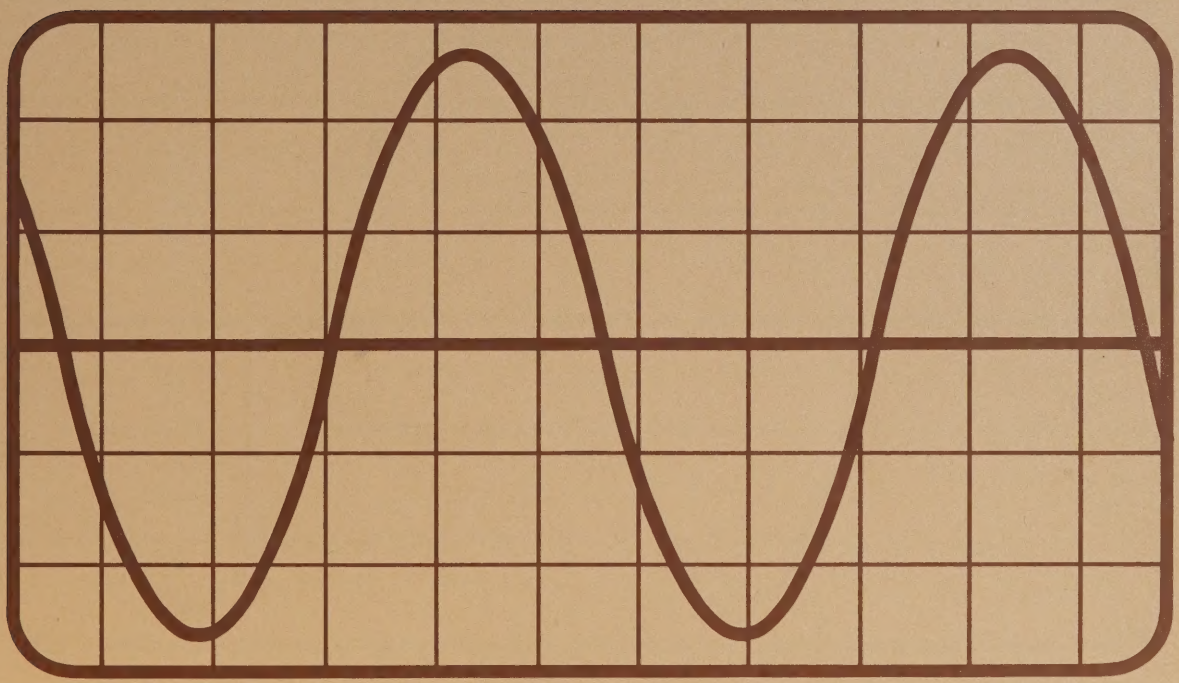
Ministry of Education
Ontario

Chris Ward, Minister
Bernard J. Shapiro, Deputy Minister

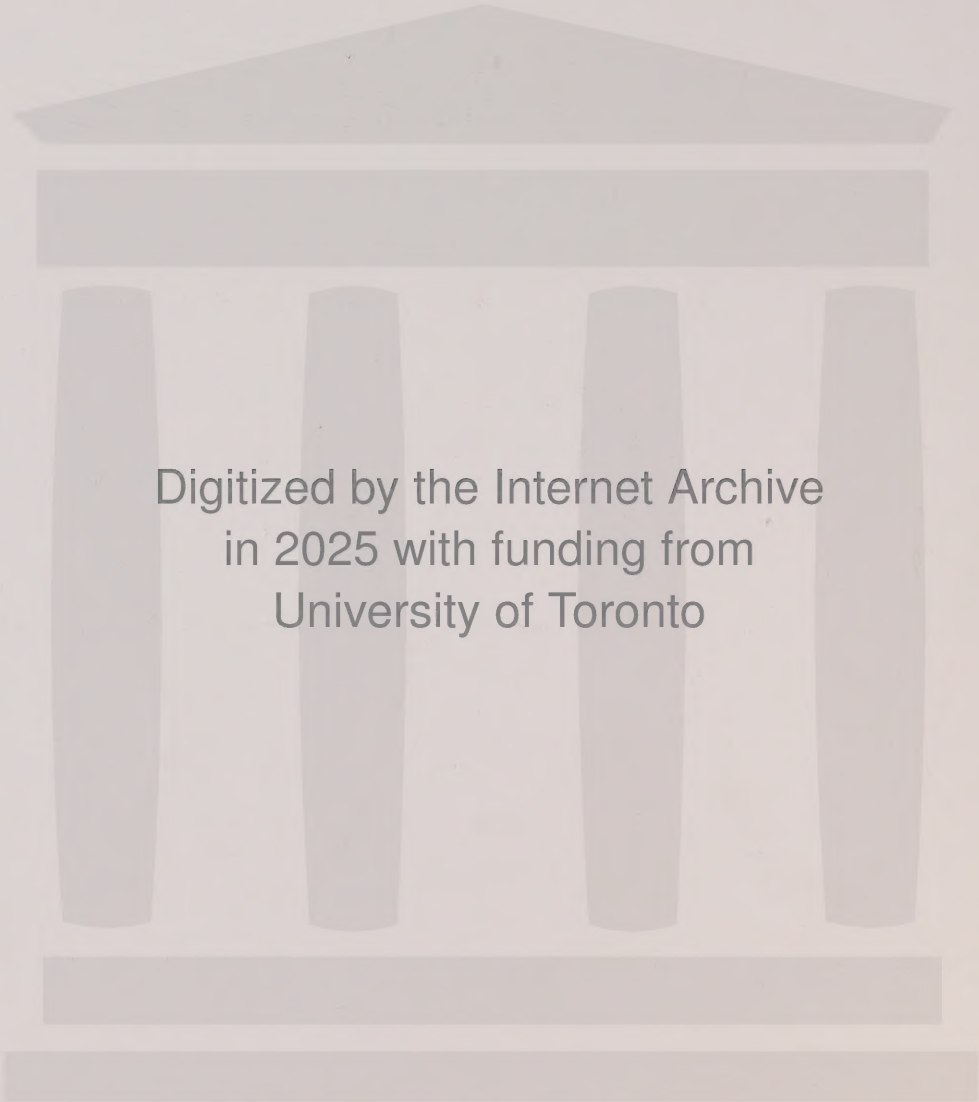
SENIOR DIVISION ADVANCED-LEVEL PHYSICS

Educators' Report



PROVINCIAL REVIEWS
CHEMISTRY AND PHYSICS

Program
Implementation
and Review Branch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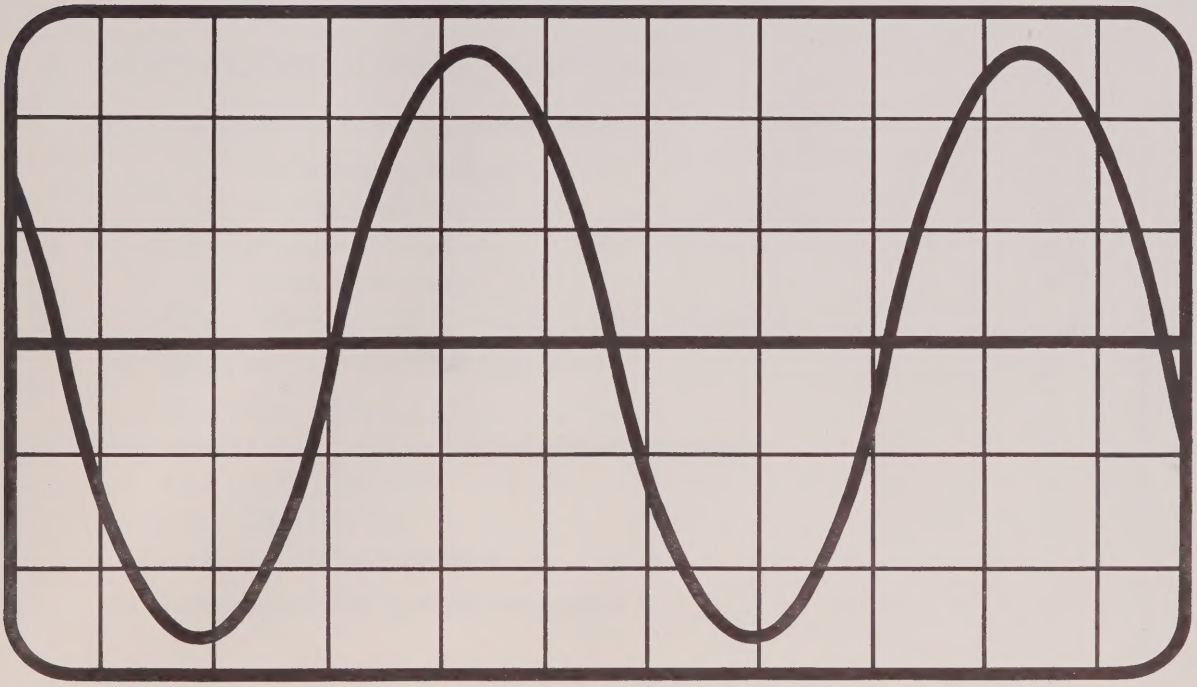
SENIOR DIVISION ADVANCED-LEVEL PHYSICS

Educators' Report



PROVINCIAL REVIEWS

CHEMISTRY AND PHYSICS

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SENIOR DIVISION ADVANCED LEVEL PHYSICS

EDUCATORS' REPORT

1. CURRICULUM MANAGEMENT IN ONTARIO

In recent years, several developments have led to a need for the reviewing and clarifying of curriculum policies, processes and responsibilities at both the provincial and local level. These developments include:

- a demand by the public for increased responsiveness and accountability on the part of educators;
- economic and technological changes as they affect school programs;
- an emerging consensus in the educational community on the cyclic nature of review, development and implementation functions;
- many publications focussing on implementation and evaluation;
- indications, from research and reviews, that school boards have experienced widely varying degrees of success in addressing curriculum review, development and implementation.

The Ministry of Education in Ontario has adopted the cyclic process of Curriculum Review Development and Implementation (CRDI) as a major concept in the management of curriculum. The Resource Guide *Curriculum Management* (1988) provides a useful summary of the concept and its application to education in Ontario.

An integral part of the CRDI cycle is the **Review** component, which can be defined as "the systematic gathering, analysis, interpretation and evaluation of information concerning educational programs". Reviews can provide information that will both provide initiatives and direction for program improvement as well as providing for public accountability.

As a part of the CRDI process at the Provincial level, the Ministry of Education has embarked upon a program of Provincial Reviews. These reviews form a part of the Ministry of Education's ongoing commitment to the monitoring of programs in all subject areas and help to inform the public about the performance of the Ontario educational system. Reviews are conducted by the Ministry of Education for the following purposes:

- To provide a curriculum-based process of public accountability for the province and for local boards of education.

- To determine the level of student achievement and program effectiveness at the provincial level as a basis for public reporting and decision making.
- To identify strategies that will enable local program improvement and ensure the effective implementation of Ministry guidelines.
- To establish baseline information on both student achievement and program effectiveness for comparison with future reviews.
- To provide instruments, procedures and baseline information for use by schools and boards in local reviews.

This ***Report to Educators*** is designed to present, in detail, the results of the *Provincial Review of Senior Division Advanced-Level Physics*, which was conducted in the spring of 1988. A summary document, *Physics - A Report Card for Ontario* has also been prepared.

2. SCIENCE IN ONTARIO SCHOOLS - A CURRICULUM IN TRANSITION

A great deal of attention has been paid recently to science education at both the national and provincial levels. A number of studies and reports have prompted the initiation of the first major reform of science education in 20 years.

2.1 Research in Science Education

An important initiator of this reform was the Science Council of Canada Study in 1984. The report, *Science for Every Student: Educating Canadians for Tomorrow's World*, indicated that science is not taught in a way that reflects the nature of science nor is it taught in a way that has any relevance to students in terms of societal implications or applications. At approximately the same time (in 1985), a research study, the *Second International Science Study* (SISS) was carried out under the auspices of the International Association for the Evaluation of Educational Achievement (IEA). While the Science Council report was designed to influence policy and stimulate discussion on science education, the latter study was intended to provide a database which might be used by policy makers. Ontario's results are reported in the *Ontario Science Report Card(1987)*

A complementary study carried out by the Science Teachers' Association of Ontario (STAO) produced a position paper on science curriculum. This position paper *A Rationale for Quality Science Education in the Schools of Ontario* presented 46 recommendations for curriculum development in science in Ontario.

2.2 Ontario Ministry of Education Initiatives

The Ontario Ministry of Education has undertaken a number of initiatives to renew the science curriculum including:

Ontario Assessment Instrument Pools for Chemistry and Physics (1982): - a large pool of assessment instruments in a number of subject areas. OAIP pools for senior division chemistry and physics were released in 1982, and extensive field trials of these were conducted in 1983.

Science: Intermediate and Senior Divisions (1987): - a new guideline for all science courses in the Intermediate and Senior Divisions. The knowledge component of many of the courses has not changed from previous guidelines. However, significant changes have been mandated in the approach to the teaching of science in Ontario.

Science is Happening Here (1988): - a policy statement for science in the Primary and Junior Divisions.

It is expected that both current and future Provincial Reviews of various aspects of the science curriculum will provide appropriate "snapshots" of the existing curriculum against which to measure the implementation of these new initiatives.

3. INTRODUCTION TO THE PHYSICS REVIEW

The Provincial Review in Senior Division, Advanced Level Physics was carried out at two levels:

At the provincial level, where a representative sample of schools was chosen; and

At the board level, where boards were given the opportunity to conduct a board review involving all schools in which Senior Division Advanced Level Physics was taught.

Since compulsory implementation of the new guideline was scheduled to begin in September 1989, units common to both the existing guideline (*S-17A 1966*), and new guideline (*Science: Intermediate and Senior 1987, Part 14*) were chosen for review.

Data collected from schools involved in the provincial review provide the basis for provincial reports, while school boards who chose to be involved, receive board results.

3.1 Features of the Provincial Review Process

Provincial Reviews in Ontario are a curriculum-based approach to program assessment. The process includes the collection of data on the **Intended, Implemented, and Attained Curriculum.** This model for program reviews has evolved from Ontario's participation in the Second International Mathematics Study (SIMS) during the years 1980 - 1983.

Information was gathered from students, teachers and school boards in Ontario. More than 12 000 students and their teachers participated in the provincial sample. These participants came from 186 schools offering instruction in English, as well as all 40 schools in which the course was given in French. Individual students and teachers were not identified in the review results.

The review collected the following information:

- courses of study prepared at the school level to indicate learning objectives, teaching strategies, evaluation techniques and resources
- details about teaching strategies used in the physics classrooms including resources, methodologies, evaluation techniques and instructional time
- student achievement data indicating knowledge of physics, the application of physics concepts and the ability to perform tasks involving advanced thinking skills.
- student attitudes toward physics and the physics course.

In this review, student achievement was measured in six content areas. These areas were common to the guideline issued in 1966 and used in schools in the province and to the newly released guideline, which was being implemented by some schools. These were:

1. **Mechanics:** - speed, velocity and acceleration, force, Newton's Laws of Motion, gravitational force, work, energy and power
2. **Waves and Sound:** - vibrations and waves, the wave equation, interference of waves and sound, and resonance
3. **Light:** - reflection and refraction including index of refraction, lenses, and optical instruments

4. **Current Electricity**: - electrical circuits, resistance, Ohm's Law, power and the cost of electrical energy
5. **Electromagnetism:** - magnetism, electromagnetism, the motor principle, electromagnetic induction, motors and transformers
6. **Atomic Structure and Nuclear Physics**: - atomic structure radioactivity, structure of the nucleus, nuclear reactions, fission, fusion, and applications of nuclear physics.

In addition to these six specific content areas, students were also asked their opinions about their approach to learning physics, science education in general, the use of computers, and the role of science in society.

3.1.1 The Intended Curriculum

The primary source of the intended curriculum in Ontario is the Ministry of Education Guideline. A new guideline for Senior Division Advanced Level Physics was released in the fall of 1987, with implementation in September 1989.

3.1.2 The Implemented Curriculum

The **Implemented Curriculum** was investigated by asking teachers about their teaching of the objectives found in the provincial guidelines, their instructional practices, methods of evaluation, and resources used. Teachers were also asked to describe their instructional use of microcomputers.

3.1.3 The Attained Curriculum

Information on the **Attained Curriculum** was obtained by assessing student achievement on a selection of questions. A team of chemistry educators chose 100 selected-response (multiple-choice) questions, 95 of which came from the Ontario Assessment Instrument Pool (OAIP) - Physics, published in 1982. Five extended-response questions were also designed by the team, based on questions found in the OAIP.

Students were asked questions concerning their background and study habits, and their opinions on a on variety of science-related topics.

3.1.4 Review Administration

The data collected was scored and analysed by the Ministry of Education. A study of the student achievement results from the Provincial sample was done by a Provincial Interpretation Panel. This panel, composed of representatives of the science education community, trustees and representatives from the public at large rated student performance on the selected-response and extended-response questions. Further details of this process, and the results can be found in Section 10.1.4 and in Displays 51 and 52.

School and board results for local reviews have been prepared and distributed. This report represents aggregated data from the schools in the provincial sample only.

3.1.5 Comments on the Review Process from Participants

Following the data collection phase, surveys were conducted in which samples from three groups of participants were asked their opinions regarding the review process.

Responses from a random sample of participants, both teachers and administrators, indicated that the review was generally well received. Teachers were interested in the results and in ways that they may be applied in the school. The instruments and questionnaires were generally well received and teachers andschool contacts were on the whole very pleased with the assistance provided in administering the review.

Confidentiality did not appear to be a major problem for most teachers, and concerns expressed by some respondees will hopefully be alleviated by the manner in which the results of the review are handled both provincially and locally. Concerns expressed about motivation of both students and teachers hopefully will be eased as educators become more familiar with the content

and process of reviews. Quality communication between the Ministry and review participants will help build confidence in the review process.

3.2 NATURE AND SETTING OF THE PHYSICS REVIEW

3.2.1 Senior Division Advanced-Level Physics

This course is the first part of the Advanced-Level Physics program in Ontario schools, the second and final part being OAC Physics. The Senior Division course is usually taken by students during either their third or fourth year of secondary school. Students taking it are often planning post-secondary education. Many students follow this course with the OAC Physics course to prepare them for university programs in the sciences.

The process of implementation of the new guideline is at various stages across the province. Traditionally the course has been offered at the Grade 11 level, often preceding a Grade 12 Chemistry course. The new guideline suggests that the Senior Division Advanced-Level Physics course (SPH 4A), be taken during the fourth year, following the Chemistry course (SCH 3A). Since both courses are at the Senior Division, students may take them in any sequence.

3.2.2 Program Frameworks and Curriculum Emphases

Although the questions in the student assessment section of the review were directly related to content domains which were common to both the existing guideline and to the new guideline, the teaching strategies used or frameworks within which content is presented can vary widely. In the context of this report, a **program framework**, can be considered to be the general basis upon which decisions about teaching strategies are made. For example, in the past, many teachers may have taught their course based on a particular textbook. Other teachers may have focussed on student laboratory activities as a program framework. Other possibilities for program frameworks include cooperative education, independent study, and more teacher-centred methods.

One framework around which curriculum can be designed that encourages such discussion of issues mandated by the new guideline is that of **Curriculum Emphases.**[10] The intent of this form of curriculum planning is to make science much more relevant for the student. In the teaching of science, content must be accompanied by a purpose. The content of a course specifies what is to be taught, while the purpose deals with the issue of why the content is to be learned. Curriculum emphasis deals with the purpose. Roberts(1982)[11] describes curriculum emphases as follows:

> A curriculum emphasis in science education is a coherent set of messages to the student about science (rather than within science). Such messages constitute objectives which go beyond learning the facts, principles, laws and theories of the subject matter itself - objectives which provide answers to the student question: "Why am I learning this?"

Teachers implementing the new guideline will be starting to use a number of curriculum emphases upon which to build their program.

These curriculum emphases can be grouped under five general headings:

1. Solid Foundations Emphasis
2. Nature of Science Emphasis
3. Practical Applications Emphasis
4. Science Technology and Society Emphasis
5. Communication

Traditionally, many science courses have been designed around only one emphasis, Solid Foundations. The introduction of alternative curricular emphases constitutes one factor that should affect both student achievement and student retention. Research has shown that student achievement is closely related to such approaches to the teaching process. A recent Ontario example is found in the

report on the 1983 OAIP Field Trials in Chemistry.[12] This report cited evidence that student achievement was **positively** correlated to the discussion of scientific issues and values, while **negatively** correlated to doing problems in class.

Factors affecting student achievement are many and varied, including such factors as the availability of resources, time spent on topic, teaching strategies, the board implementation plan, and availability of laboratory facilities.

Since this review examined material common to both the 1966 and the 1987 guideline, student assessment questions do not reflect all of the emphases that are being implemented by those teachers using the new guideline. Subsequent reviews will measure the real effectiveness of this curriculum renewal.

3.2.3 Sample Selection

Reviews were conducted in both English and French-language schools. Two kinds of reviews took place: Provincial Reviews and Board Reviews. Among English-language schools, a Provincial Review sample of 187 schools, 312 teachers and 11 169 students provided data representative of the entire English-language population of 580 schools, 970 teachers, and 55 000 students involved in Senior Division Advanced Level Physics. The Provincial Sample schools were chosen to reflect the diverse nature of Ontario. For example, schools representing all geographical areas were chosen, as well as urban and rural schools, schools from both public and separate boards, and both large and small schools. The data collected from the schools in the Provincial Review Sample is presented in this report.

All French-language schools participated in the Provincial Review. The results from these 43 schools, 44 teachers, and 1221 students are presented in the French-language *Senior Division Advanced Level Physics - Educators' Report.*

Apart from the provincial sample, 39 school boards chose to participate in the Provincial Review process by conducting Board Reviews in Senior Division Advanced Level Physics. All of the 251 schools, 376 teachers, and their students in these boards participated. (Some English-language board review schools were also part of the provincial sample, and boards which had more than one French-language school automatically qualify to receive a report for these schools.) Board Results for Physics have been prepared and distributed for each school board which undertook a board review as well as for those containing more than one French-language school.

Each school board that contained more than one French-language school also received board results for these schools as well. These boards received these results by virtue of every French-language school being involved in the provincial review.

Additionally, **school results** are being provided to every school which participated in the review. The results for schools which participated as part of a board review are identical to those being provided to those selected as provincial sample schools. Individual school boards involved in board reviews are expected to analyze and interpret the board data and to report publicly on the results.

3.2.4 Data Collection

Several data collection instruments were used to assess the intended, implemented and attained curriculum.

Information on the **intended curriculum** was obtained from two sources:

A **Course of Study Analysis** carried out on courses submitted by a provincial sample of 100 schools. These were analysed by a team of Ontario science educators. This team determined whether each of a variety of components were present in these documents.

A **Teacher Data Questionnaire** which collected information on teacher opinions and teacher background. This was completed by all teachers.

Analysis of the **implemented curriculum** was carried out using data obtained from three sources:

A **Teacher Practices Questionnaire** which collected information on the instructional practices of teachers such as resources, methodology, evaluation techniques, and instructional time allotment.

A **Curriculum Management Questionnaire** which collected information on curriculum management at the school level and the impact on the Physics program. This was completed by the department head or other person responsible for Senior Division Advanced Level Physics.

An **Opportunity-to-Learn (OTL) Questionnaire** which all teachers completed, indicating whether students had been taught the concepts and skills necessary to answer the student assessment questions, as well as teacher predictions of student achievement for each question.

The **attained curriculum** was assessed through student responses to questions designed to measure student knowledge and skills, and attitudes toward Senior Division Advanced-Level Physics. 100 selected-response (multiple-choice) questions, and five extended-response questions were involved in this section of the review.

3.2.3 Multiple Matrix Sampling

To collect reliable data about student achievement on a large part of the curriculum, 100 questions were asked of the students. To limit the amount of time needed for the assessment and to provide data on a broader range of elements of the curriculum, **multiple matrix sampling** was used.

Both selected-response and extended-response questions were distributed among five test booklets. The booklets were rotated through each class and each student completed one booklet. The responses obtained from having one-fifth of the students answer each question are generalized to represent student achievement for all students. For most school boards, and for larger schools, these generalizations are very accurate. The document *Guidelines for Determining the Accuracy of Student Achievement Scores*, will assist in the proper interpretation of these results.

All of the questions were related to the six content domain areas selected for the Review and were also classified by process level (Knowledge, Application, or Higher-Order Skills). Each booklet contained a different group of attitudinal questions related to the following areas:

- student activities in the laboratory,
- science and chemistry as a career,
- the effect of science on society,
- the nature of science,
- specific aspects of the course in physics.

A complete list of questions found in each booklet is found in Appendices 1 and 2. Students were permitted access to calculators, mathematical instruments and trigonometric tables during the review process.

3.3 RELIABILITY AND VALIDITY OF THE INSTRUMENTS

When the questions were selected for the student assessment section of the review, consideration was given to both reliability and validity. **Reliability** refers to the consistency of responses to these questions from day-to-day or, in the case of multiple-matrix-sampling, the consistency of responses to a set of items by a sample of students within a school. **Validity** refers to the degree to which the questions seem to be measuring what they are supposed to assess. A variety of methods can be used to determine both reliability and validity.

Reliability of the Questions

Information from both the results of the review, and from the OAIP Field Trials indicate that students responses to the items were indeed reliable. Field Trial p-values compare very well with

Review p-values for those questions which were included in both surveys. Further indication of reliability is the fact that schools that did well on some questions did well on them all, while the converse was also observed. In addition, the scores obtained by schools and school boards were reliable as were the differences between them.

Validity of the Items

Evaluation of the validity of questions always involves a degree of judgement on the parts of those using the questions. The individuals responsible for selecting the questions were all experienced classroom teachers of Physics and chose questions from the OAIP Pool that, in their judgement, would assess achievement in each of the content domains and in each process skill. Educators have the responsibility to pursue the questions found in any assessment instrument to determine the curricular validity of the questions for their jurisdiction. While all of the content domains were core to both the existing and new guidelines, the local frameworks within which they are presented may vary.

4. OVERVIEW OF RESULTS AND PARTICIPATION RATES

4.1 PLAN OF PRESENTATION

This report presents all of the data collected from the provincial sample for the Provincial Review in Physics. All of the Displays found in school and board reports contain the same kinds of data found in the provincial report and are numbered identically. Display 1 in these results, for example, contains the same kind of data (Participation Rates) as Display 1 in school and board reports. The use of the common numbering

Display 1
Participation Rates
Provincial Results - Physics

Instrument	*Number Eligible*	*Number Returned*	*Return Rate (%)*
Course of Study (SCH)	100	91	91
Curriculum Management (SCH)	185	181	98
Teacher Data Questionaire (T)	230	227	99
Teacher Practices Questionaire (T)	230	224	97
Student Opportunity-To-Learn Form (T)	230	217	94
Student Assessment Booklets (Sets) (S)	230	225	98

Level at Which Data Was Provided SCH=School T=Teacher S=Student

scheme permits the comparison of the three levels of results.

4.2 PROVINCIAL, BOARD AND SCHOOL RESULTS

For schools and school boards who participated in board reviews, student data collected are reported at the school, board, and provincial level. Board results contain the data collected from students aggregated at the board level; that is, all the data from the students in the school board are presented as a whole. This data includes student background information, achievement, and attitude results.

Teacher data, except for the summary graphs concerning student opportunity-to-learn, as well as all information provided by the department heads concerning curriculum management, are to be found at the board and provincial level. No data of this type was reported at the school level.

Schools and school boards will be able to use the data collected to identify strengths and weaknesses in their programs. It is hoped that the data will stimulate useful discussion among science educators as they continue the implementation of the new science guideline. Individual school boards who opted for a board review are expected to analyze and interpret board data and to report publicly on the results. Comparison of individual schools is **not** appropriate.

All of the data collected from the provincial sample is presented in this provincial report. Display 68 provides details concerning the kinds of results reported at the school, board, and provincial levels.

Without the high degree of cooperation given by the many teachers, students and administrators who participated, this review could not have taken place. The professional approach of the educators of Ontario in responding to and administering the review was greatly appreciated.

4.3 PARTICIPATION RATES

The Department Head in each participating school provided information by means of the Curriculum Management Questionnaire. Each teacher of physics was asked to complete a Teacher Data Questionnaire, a Teacher Practices Questionnaire, and a Student Opportunity-To-Learn Form. Students completed Student Assessment Booklets.

Display 1 provides the number of eligible schools and teachers in the provincial sample, the number of questionnaires returned, and the percentage returned. The number of eligible Curriculum Management Questionnaires indicates the number of schools in the provincial sample offering Senior Division Advanced Level Physics either during the second semester or as a full-year course. The participation rates are very high, indicating that the results obtained are representative of the students and teachers in the province.

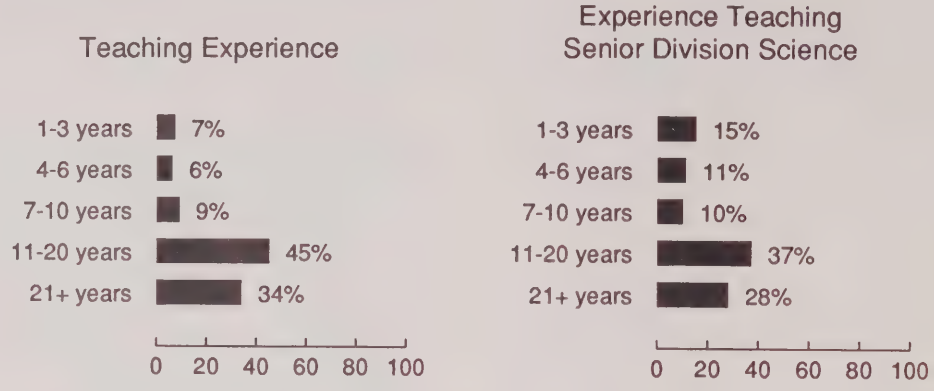
5. THE TEACHER OF SENIOR DIVISION ADVANCED LEVEL PHYSICS

A number of displays provide information about the qualifications and experience of teachers of Senior Division Advanced Level Physics.

5.1 Teaching Experience

Display 2 shows the range of teaching experience among teachers as well as the amount of accumulated experience teaching Senior Division Advanced Level Physics.

Display 2
Percentage of Teachers with Varying Years of Teaching Experience and Experience Teaching Senior Division Science
Provincial Results - Physics



Most physics teachers in the province are quite experienced. Almost 80 percent have eleven or more years teaching experience. The data also indicates that some new science teachers are entering the profession.

Sixty-five percent have been teaching physics for eleven or more years. The difference between experience teaching senior division physics and the number of years in the profession may indicate an increase in the number of "cross-over teachers", that is, teachers of other subjects who teach in other subject areas due to changes in enrolment patterns.

5.2 Background and Qualifications

Display 3 provides a variety of information detailing teachers' educational background in science and the percentage of teachers of physics who have obtained special qualifications.

Physics teachers have taken an average of more than 8 physics courses at the post-secondary level, more than twice the average number of chemistry courses taken. However, considerably more physics teachers have specialist qualifications in chemistry than physics. Only 10 percent have specialist qualifications in physics.

5.3 Professional Development

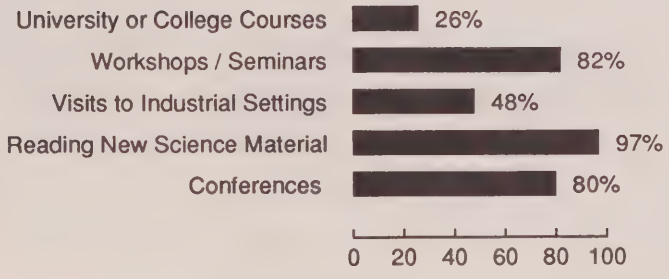
The very nature of science and science education dictates a need to keep current in both knowledge about science and the methods by which that knowledge is conveyed to students. Teachers use a variety of methods to keep their science knowledge up-to-date. Display 4 indicates the percentage of teachers who indicated involvement in various professional development ac-

Display 3
Teachers' Reports of Their Educational Background and Special Qualifications
Provincial Results - Physics

Science Background	*Courses*
Average Number of Year Long Chemistry Courses in Post Secondary Education	3.9
Average Number of Year Long Physics Courses in Post Secondary Education	8.4

Special Qualifications	*Percentage*
Teachers with Specialist Qualifications in Chemistry	15
Teachers with Specialist Qualifications in Physics	10
Teachers with Graduate Degree in Chemistry	51
Teachers with Graduate Degree in Physics	29
Teachers with Graduate Degree in Education	32

Display 4
Percentage of Teachers Using Various Methods for Keeping Science Knowledge Up-to-Date
Provincial Results - Physics



tivities. Almost all teachers report reading new science material. In addition, 80 percent use their attendance at workshops, seminars and conferences as a method for increasing professional competencies. This reflects the active involvement of many science teachers in the province in their professional organizations, particularly the Science Teachers' Association of Ontario which promotes science education through its publications and conferences.

5.4 Class Sizes

Teachers reported the number of classes they were currently teaching and the enrollment in each class. The percentage of classes taught at various enrollment sizes are presented in Display 5. Classes most frequently have enrollments of 21-30 students.

Information about teacher instructional practices and content coverage is presented in the section concerned with the implemented curriculum.

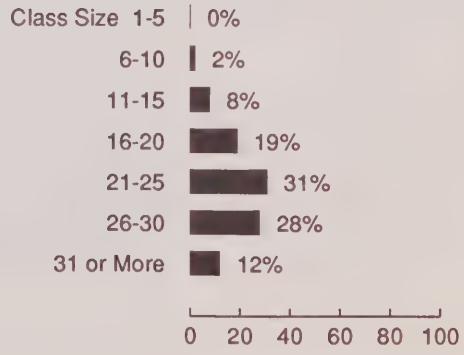
6. THE STUDENT OF SENIOR DIVISION ADVANCED LEVEL PHYSICS

To obtain a profile of the student enrolled in Advanced Level Senior Division Physics, students answered questions about their interest in science, extracurricular science pursuits, and classroom activities. They also provided information about

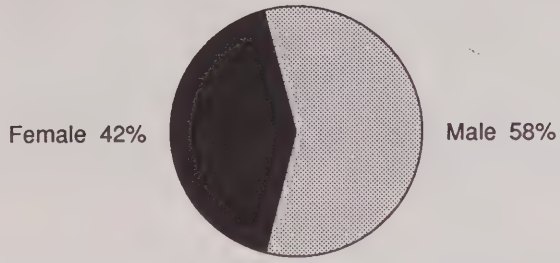
- amount of homework assigned
- plans for further education
- use of computers in their school and at home
- the amount and type of employment

the everyday activities which take place in their physics classrooms.

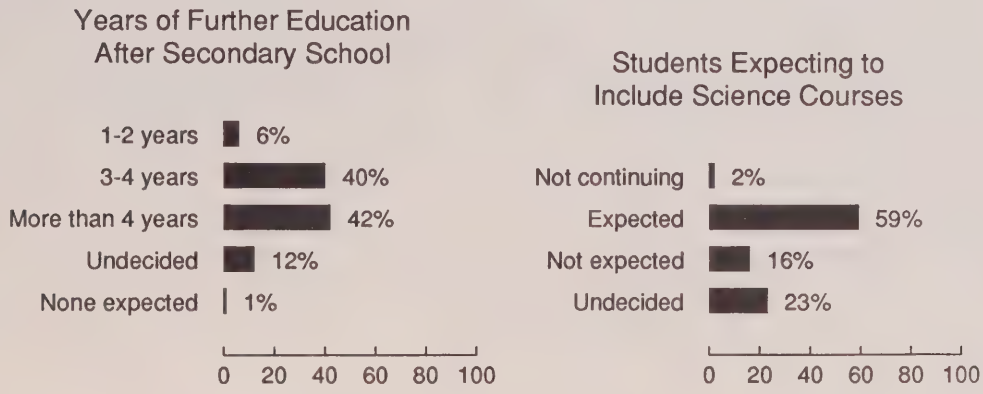
Display 5
Percentage of Classes Reported
Taught at Varying Class Enrollments
Provincial Results - Physics



Display 6
Percentage of Gender Enrollment
in the Senior Division Advanced Level Science Course
Provincial Results - Physics



Display 7
Student Reports of Future Educational Plans
and Whether Science Courses Are Included in These Future Plans
Provincial Results - Physics



6.1 Gender Enrolment in the Physics Course

Display 6 presents the percentage of males and females enrolled in Senior Division Advanced Level Physics. Almost 60 percent of the students are male. Males represent a higher percentage of the total student population in physics than in either chemistry or biology.

6.2 Student Plans for Post-Secondary Education

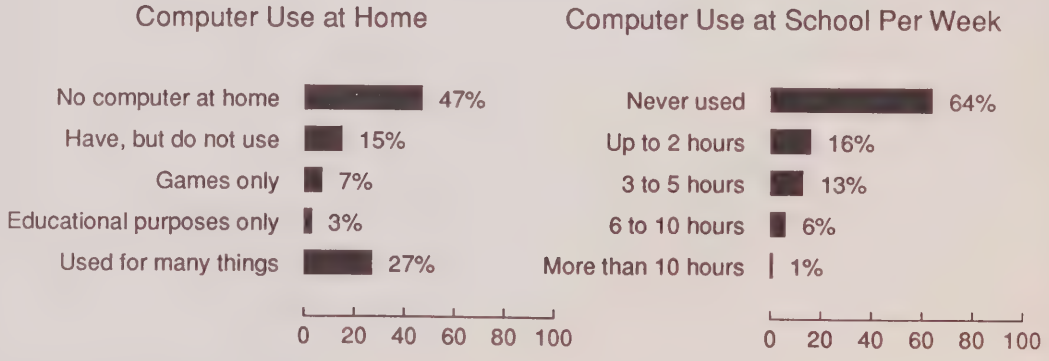
One consideration that enters into the interpretation of these results is the plans of students for post-secondary education. Display 7 shows both students' intentions to pursue science beyond secondary school as well as the number of years they expect to spend in further education. One graph shows the percentage of students indicating each of the possible response options ranging from no plans for further education through more than 4 years. Almost all students are planning to take some post-secondary education. This reflects the fact that this review deals with Advanced Level science and the importance that these students place on science as part of their general education. While almost 40 percent are planning the traditional three to four years, over 41 percent indicated they plan more than four years.

The other graph shows the percentage of students indicating various plans for taking science courses. The majority plan to take science courses after high school but 23 percent have not yet made a decision in this matter.

6.3 Student Use of Computers at Home and In School

The use of computers - both in the home and at school - was a major focus of this review. Part of

Display 8
Percentage of Students Reporting Use of a Computer for Various Activities at Home and Hours of Use of a Computer at School
Provincial Results - Physics



the information related to computers is provided in this section with further detail provided later in section 6 where teachers describe their use of the computer in school. Many students have access to computers, both at home and in school. Students provided information on whether they had a computer at home and if so, the uses made of it. Display 8 shows that over half of the students have a computer at home and 27 percent use it for a variety of purposes. On the other hand 15 percent do not use the computer at home.

Students also indicated the amount of time they use a computer at school. Just over one-third use computers at school, usually for up to 2 hours per week. Some of these students were taking a com-

Display 9
Students' Reports of Frequency of Various Classroom Activities
Provincial Results - Physics

Classroom Activity	*Frequency of Occurrence*				
	4 Times Per Wk.	*3 Times Per Wk.*	*Twice Per Wk.*	*Once Per Wk.*	*Never*
How often does the teacher do demonstrations?	8	18	33	36	4
How often does the teacher distribute notes?	18	15	17	24	25
How often does the class copy the teacher's notes from the chalkboard/ overhead projector into notebooks?	48	27	13	9	3
How often does the class work in small groups (2 to 5 students) to do experiments?	4	11	26	49	9
How often do members of the class do experiments in science individually (without any lab partners)?	1	1	2	15	81
How often do members of the class use a computer?	1	1	2	5	91
How often does the teacher use the students' ideas and suggestions when planning science lessons?	2	3	8	26	60
How often does the class use library or resource books?	3	3	5	21	67

puter course, which would tend to inflate these figures.

6.4 Science Activities in the Classroom

The greatest exposure that students usually have to science in general, and physics in particular, occurs in their classroom. Students' reports of activities are an important window into their perceptions of science and how it is taught and learned. Students indicated the number of periods per week that their class was involved in a variety of activities.

Display 9 shows that most teachers do demonstrations once or twice per week. Although individual experiments are rarely used, small group work does occur, usually once a week. About 14 percent of the students have participated in a science fair. Computers appear to have had little impact in physics classes since over 90 percent of the students never use computers in their learning of physics in school.

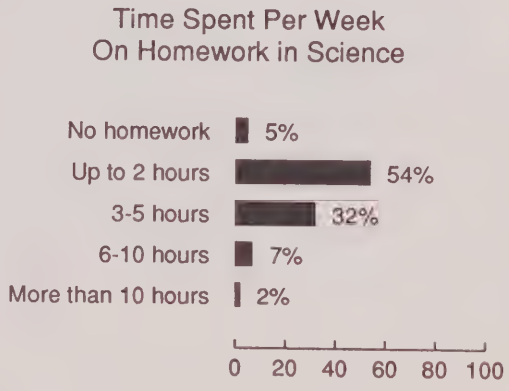
By far the most frequent activity reported was copying notes from the chalkboard/overhead projector into notebooks. Teachers also distribute notes but the frequency varies widely. Library or resource books are rarely used in class. Students have little input into the planning of science lessons, perhaps reflecting the technical nature of the subject.

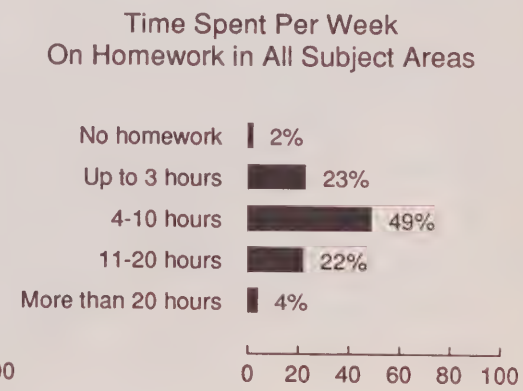
The new guideline both suggests and prescribes a number of teaching and learning activities. Specific student activities are mandated in each unit of the new course. Teachers are also encouraged to make use of such facilities as libraries and computers. The use of independent syudy and cooperative learning is also encouraged.

6.5 Student Homework

Display 10 shows student reports of the number of hours spent per week on homework in science and other courses. The majority spend up to two hours a week on physics homework or other school work related to the subject. The majority

Display 10
Student Reports of Number of Hours Spent Per Week on Homework in Science and Homework in All Subject Areas
Provincial Results - Physics





of students report spending 4 - 10 hours per week on homework assigned in all their subject areas.

6.6 Reading and Watching Television

Display 11 compares students' reports of watching television with reading. The majority of students report spending 1-3 hours per day watching television and approximately 1 hour reading.

6.7 Student Employment

Students frequently hold outside employment during the school year. Display 12 indicates the percentage of students who work and the number of hours worked per week. Over two-thirds of the students have a job and a large majority of these work both weekdays and weekends. Most students work part-time for between 11 and 20 hours per week.

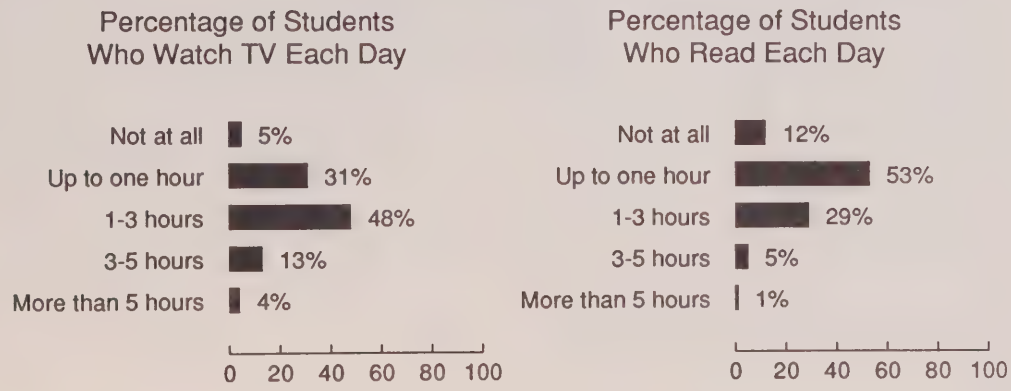
6.8 Out-of-School Science Activities

Although the major exposure for students in the area of science is in the classroom, science education is not limited to this venue. Students have the opportunity to read about science or watch science programs on television. Display 13 shows the percentage of students reporting their out-of-school involvement with science. Outside of the classroom information about science reaches students most frequently through television, newspapers, science magazines and weekly magazines. Although over 50 percent said they watch science programs on television at least sometimes, 60 percent rarely or never read magazines with a science focus or to obtain information about science.

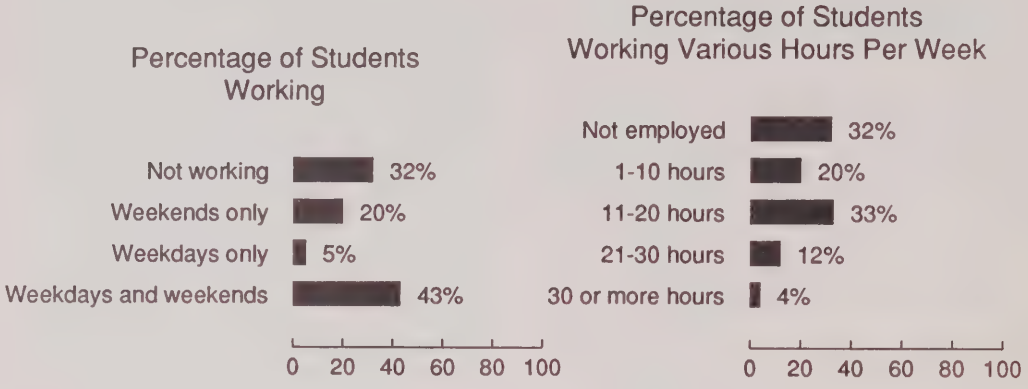
6.9 Science Fairs

One of the popular activities in both elementary and secondary schools in Ontario is the science

Display 11
Percentage of Students Reporting Varying Amounts of Television Watching and Reading Each Day
Provincial Results - Physics


Percentage of Students Who Watch TV Each Day
Not at all 5%
Up to one hour 31%
1-3 hours 48%
3-5 hours 13%
More than 5 hours 4%
0 20 40 60 80 100
Percentage of Students Who Read Each Day
Not at all 12%
Up to one hour 53%
1-3 hours 29%
3-5 hours 5%
More than 5 hours 1%
0 20 40 60 80 100

Display 12
Percentage of Students Reporting Various Employment Activities and Number of Hours Spent Per Week Working
Provincial Results - Physics


Percentage of Students Working
Not working 32%
Weekends only 20%
Weekdays only 5%
Weekdays and weekends 43%
0 20 40 60 80 100
Percentage of Students Working Various Hours Per Week
Not employed 32%
1-10 hours 20%
11-20 hours 33%
21-30 hours 12%
30 or more hours 4%
0 20 40 60 80 100

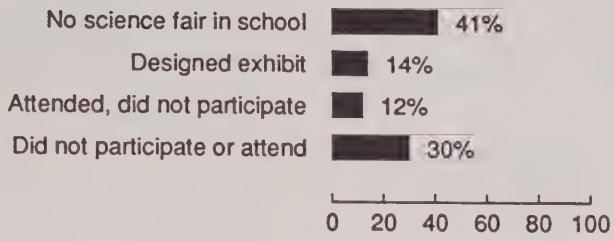
fair. Students indicated whether their schools held science fairs and the extent of their participation in such activities. Display 14 reports the extent of students' participation in school science fairs. Almost 60 percent of the schools have science fairs and about 14 percent of the students participated by preparing exhibits.

Information concerning students' attitudes towards science and careers in science are described in the section concerned with the attained curriculum together with results of performance on the student achievement measures.

Display 13
Percentage of Students Reporting Various Out-of-School Activities Concerned With Science
Provincial Results - Physics

Out-of-School Activities	*Often*	*Sometimes*	*Rarely*	*Never*
Reading About Science in a Newsweekly	7	30	37	26
Reading Science Magazines	11	29	32	28
Reading About Science in the Newspaper	8	36	37	19
Watching Science Programs on Television	16	37	28	19

Display 14
Percentage of Students Reporting Various Levels of Involvement in School Science Fairs
Provincial Results - Physics



7. THE INTENDED CURRICULUM

The main source of the intended curriculum in Ontario is the Ministry of Education Guideline. The curriculum for Senior Division Advanced Level Physics is currently in transition. Since 1966 the curriculum has been defined by *Curriculum S-17A: Physics Senior Division, Grade 12 Five Year Program.* In 1987 a new curriculum guideline was released: *Science, Intermediate and Senior Divisions 1988, Part 14 Physics Grade 11 Advanced and OAC.* During the period of the review, both documents were being used as a source of the intended curriculum in Ontario schools.Additional aspects of the intended curriculum are schools' courses of study. This review examined courses of study obtained from a sample of provincial review schools and teachers in both the provincial review and all board reviews answered questions about the components of their courses of study.

7.1 ANALYSIS OF COURSES OF STUDY

As part of the assessment of the intended curriculum at the provincial level, a sample of 100 schools provided courses of study to the Ministry which were examined by a team of Ontario Physics educators.

The transition between two guidelines posed a problem for the course of study analysis team. Many of the courses were based on guideline S-17A(1966), in which there is no indication of requirements for courses of study. However, Part 1 of the new Intermediate/Senior Science Guideline (Program Outline and Policy) is quite specific in describing requirements for courses of study. To provide a common set of criteria that was applicable to both guidelines it was decided that therequirements described in OS:IS would form the basis for the analysis. A number of criteria were established. These included:

- indication of level of difficulty and credit value,

- inclusion of a description of general course objectives,
- teacher methods, and expected student outcomes,
- the presence of unit objectives and attitude, knowledge and skill objectives,
- the specification of core content,
- an indication of evaluation practices and course resources

Display 15 presents the results of this analysis.

Source and Credit Value

Most schools indicated the guideline and the credit value. All schools indicated the appropriate level of difficulty, either as a separate statement or in the course code (eg SPH 4A1). Where a guideline, (as the source document for the development of the course of study), was not indicated, the analysis team attempted to relate the content to the old or new guidelines to determine which was used as the basis for the course of study.

Objectives and Outcomes

Most courses of study indicated the general aims for the whole course, although the terminology used to describe this section varied greatly from "course objectives" to "course aims" to "rationale". Generally course objectives were stated in terms of teacher methods and content direction. Some teachers indicated objectives, especially for units, in terms of student behaviours rather than teacher objectives. However, it was noted that the attitudinal objectives in the new science guidelines were often not included if detail was provided in terms of student behaviour.

Few courses of study included unit objectives. Where these were indicated, the emphasis was on the knowledge objectives with some skills indicated and few,if any, attitudinal objectives. Every course of study provided a list of core content, often expanding upon the core content listed in the old guidelines.

Sequence

If a specific sequence was not noted, it was implied that the course content was taught in the order in which it was presented. Although not a requirement in OS:IS, timing was noted in the analysis of the courses of study as a method of validating the correlation between the questions asked in the student assessment section of the review and the content. Timing was indicated in the old guideline and is also a prescbibed element in the new guideline.

Units

The six units involved in the student assessment section of the Provincial Review were included in most courses of study. Occasionally, additional optional units were included; however, in general, the six units used in the review accounted for over 90% of class time.

Evaluation Practices

Most corses of study stated a "marks breakdown" indicating how much emphasis was placed on term work and examinations. Very few indicated evaluation practices for individual units; where these did occur, the practice was often linked to the use of the new guideline. A few course of study linked evaluation practices to objectives and strategies such as laboratory reports. The courses of study which indicated objectives in terms of student behaviours or outcomes were most likely to indicate evaluation practices associated with objectives and strategies.

Textbooks and Resources

Most of the courses of study indicated the textbook which was used; however, very few of the course of study mentioned resources as a separate category. Often the resources were implied or stated as a part of the strategies described.

The courses of study submitted for analysis varied greatly in length and in the kind of materials included. Occasionally, schools in large boards submitted what might be referred to as "an outline of a course of study" - a two or three page

Display 15
Analysis of the Courses of Study:
Percentage of Schools Containing Various Components
Provincial Results – Physics

Course Description			
Which guideline was in use?	Old 58%	New 24%	Not Noted 18%
Was level of course difficulty indicated?	Yes 96%	No 4%	
Was the credit value indicated?	Yes 71%	No 29%	
Course Objectives			
Were general course aims included?	Yes 75%	No 25%	
Were teacher methods/directions/suggestions included?	Yes 66%	No 34%	
Were student behaviours/outcomes included?	Yes 57%	No 43%	
Unit Objectives			
Were unit objectives included?	All 56%	Some 1%	Not Noted 43%
Were attitude objectives included?	Yes 24%	No 76%	
Were knowledge objectives included?	Yes 63%	No 37%	
Were skills objectives included?	Yes 59%	No 41%	
Core Content			
Was core content listed in course of study?	Yes 99%	No 1%	
Was the sequence of the course indicated?	Stated 30%	Implied 70%	
Was the time of units included?	Yes 82%	No 18%	
How many units of the provincial review were included in the Course of Study?	Four 3%	Five 12%	Six 85%
What was the approximate time devoted to the six units?	Mean 91%		Not Noted 15%
Evaluation Practices			
Were the evaluation practices for the whole course stated?	Yes 60%	No 40%	
Were the evaluation practices for individual units stated?	Yes 35%	No 65%	
Were evaluation practices for knowledge objectives and/or strategies stated?	Yes 10%	No 90%	
Resources			
Were texts indicated?	Yes 83%	No 17%	
Were other learning materials indicated?	Yes 52%	No 48%	

summary providing the essential data and referring to a board document which provided much more detail. Several courses of study were "cut and paste" versions of teacher guidebooks associated with a particular textbook. Although very thorough these lacked any indication of adaptation to the local needs of the school and students.

Some schools have obviously been implementing new programs based on draft copies of the new guidelines. Generally, these courses of study tended to be far more detailed and tended to relate objectives, strategies, evaluation techniques and resources in a meaningful and practical manner.

7.2 Teachers' Reports Concerning School Courses Of Study

While only a sample of courses of study were collected and examined by an analysis team, all teachers were asked through the Teacher Practices Questionnaire to indicate whether various components were found in their courses of study, and the degree of influence of these components upon their actual instructional activities. (If a teacher said that the course of study did not contain the components the influence upon their teaching was coded as 'none'). Display 16 provides the results for a variety of course components.

The course aims, instructional objectives, sequence and timing of objectives and textbooks and other resources were included in 83 percent or more of the courses of study examined. Special features such as safety, sex equity and multi-culturalism were included least. This component - "special features" - is emphasized in the new guidelines for physics and will receive special attention as the guidelines are implemented. The number of courses of study already incorporating some aspects of this component is commendable.

Of all the components identified, instructional objectives are seen to have the most influence on teaching activities. Textbooks and other resources also have considerable influence. Special features as might be expected - have the least influence at the present time.

8. THE IMPLEMENTED CURRICULUM

The implemented curriculum can be best defined as "what happens in the classroom" - the content covered and the methods by which teachers convey this content to students. This involves the types of resources teachers have available and use, the evaluation techniques instituted within the classroom, and very importantly, whether teachers have provided students with the opportunity-to-learn the content and skills required to answer the questions in the assessment section of the review process.

8.1 Hours Spent on Physics Topics

Six physics topics delineated the content areas of this provincial review. In order to gauge relative course emphases, teachers indicated the number of hours spent on each topic. Their responses were placed into various categories and the percentages summarized in Display 17.

The greatest amount of time is clearly spent on Mechanics. Forty five percent of teachers spend more than 30 hours on this particular topic. Prior to the new guideline the time alloted was just under 20 hours. The new guideline specifies a total of 25 hours for this unit. At the other end of the spectrum is the unit on Atomic Structure and Nuclear Physics. Seventy-six percent of teachers spend 10 hours or less on this particular unit. The timing indicated in the guideline is 10 hours (14 hours in the previous guideline). Thirteen percent spend no time on this domain even though it is a core unit in both the old and the new guidelines. One other unit electromagnetism - requires some

comment based on the number of hours spent on the topic. In most classrooms electromagnetism does not receive the time indicated in either the old or the new guideline, which specifies 15 hours for the topic.

Display 18 provides information concerning the range of time spent by teachers in the province on these topics. Mean scores sometimes obscure degrees of variation (range). Such variation might be found among a group of teachers or among schools in time spent on a topic. A useful method to examine the range of time spent on topics is through the use of "box and whiskers" charts.

Using Display 18 as an example, the line drawn in the boxes for each of the content domains is the mid-score or median. Half of the teachers in the provincial sample reported spending more time than the median, and half reported spending less time on the topic. The box includes the middle 50% of the teachers, 25% immediately above, and 25% immediately below the median. The lines extewnding beyond the boxes indicate the range of scores for an additional 40% of the teachers, 20% above and 20% below the box. Thus the box and lines (whiskers) represent 90% of the teachers in the province. The remaining 10% are "outliers", with 5% above , and 5% below.

Display 16
Percentage of Teachers Reporting Inclusion of Various Components in Their School Course of Study and the Amount of Influence of These Components on Their Teaching
Provincial Results - Physics

Course of Study Components	*Percentage Which Included Components*	*Degree of Influence Upon Teaching*		
		None	*Some*	*Much*
Rationale	78	29	54	17
Course Aims	89	13	33	54
Instructional Objectives	85	17	19	64
Sequence and Timing of Objectives	83	20	38	41
Special Features (safety, sex equity, etc.)	56	47	37	16
Teaching Strategies	67	36	32	32
Textbooks and Other Resources	83	19	31	50
Student Evaluation Techniques	77	24	30	46

Display 17
Percentage of Teachers Reporting Varying Number of Hours Spent on Topics
Provincial Results - Physics

Physics Topics	*Number of Hours*							
	0	*1-5*	*6-10*	*11-15*	*16-20*	*21-30*	*31-40*	*41-50*
Mechanics	2	1	1	1	11	40	33	12
Waves and Sound	3	4	18	42	23	9	1	0
Light	5	2	8	35	33	14	2	0
Current Electricity	1	3	16	33	39	7	2	0
Electro-Magnetism	5	10	27	43	13	3	0	0
Atomic Structure and Nuclear Physics	13	21	42	17	6	2	0	0

These "box and whiskers" charts can be of value to teachers and schools since individuals can compare their own data with those of the provincial sample of schools involved in the review.

8.2 Class Activities in Physics

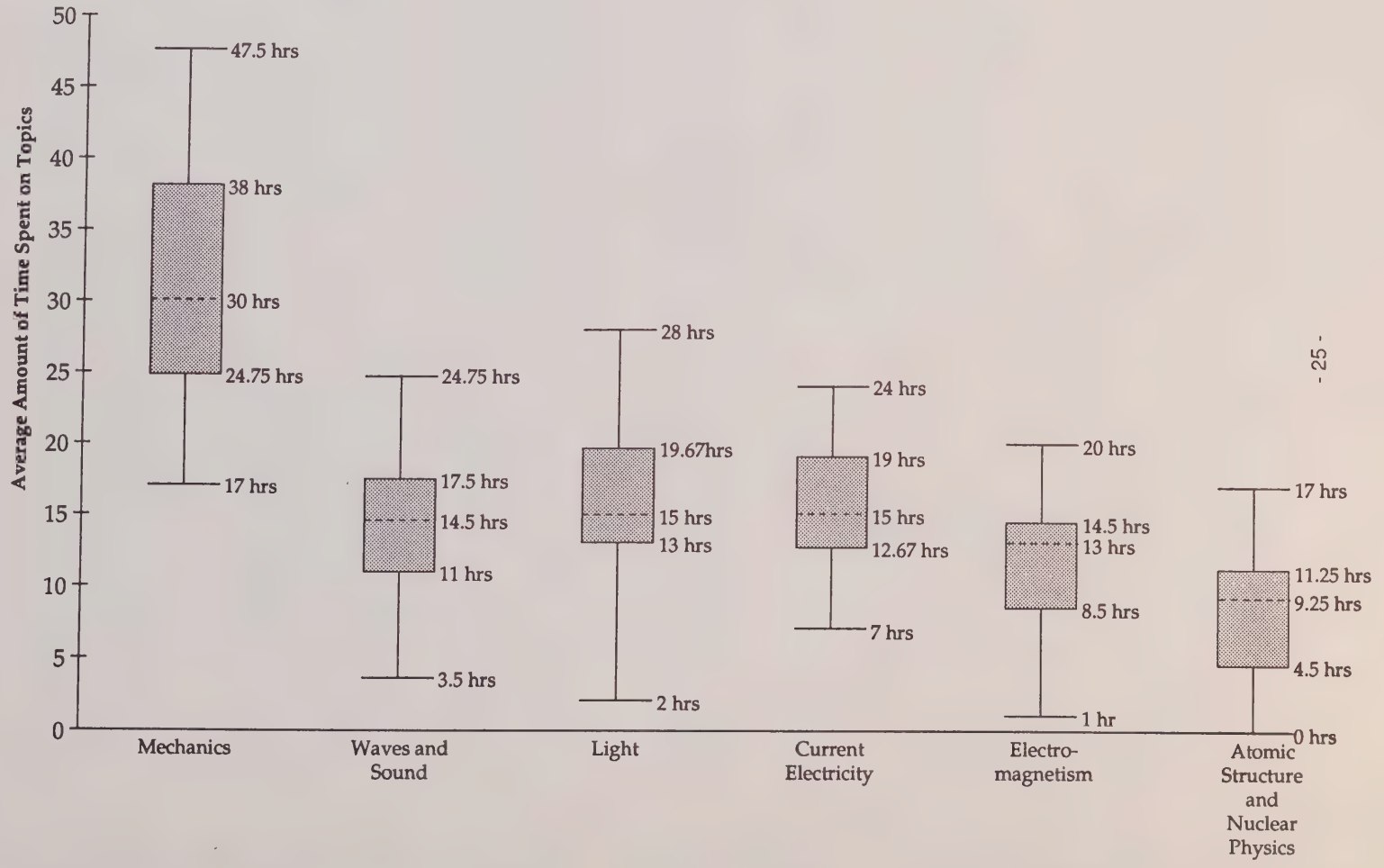
Class instructional time can be spent in a variety of ways including group or class discussions, teacher presentation, desk-work etc. Teachers approximated the percentage of time their classes were involved in these instructional activities. Display 19 shows these results. Almost two-thirds of class time is student-centred involving activities such as experiments and problem solving. As implementation of the new guideline proceeds, mandated student activities and the recommendations for a variety of teaching approaches which emphasize both the content and the process of science, should increase the proportion of student-centered work.

8.3 Student Opportunity-To-Learn

One of the best predictors of student achievement in large-scale surveys is the opportunity students have had to learn the content and skills

Display 18

Variation Among Schools in Average Time Spent on Various Topics



required to answer the achievement questions. Teachers were asked to examine each student achievement question and indicate whether students had the opportunity-to-learn the science necessary to answer the question correctly. Teachers did so by indicating whether the science necessary to answer the questions had been taught or reviewed, and if not, why not. If the teacher did not teach or review the science, one of the following reasons for not doing so was to be indicated:

- taught prior;
- taught later - in another course;
- not in the curriculum; or
- not taught for other reasons.

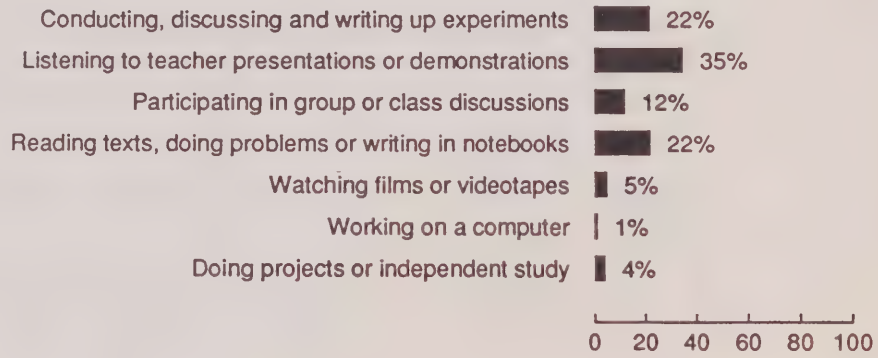
Several displays provide different views of the opportunity-to-learn provided by physics teachers. The data in these displays are based upon weighting of teacher responses by the numbers of students taught by each teacher. That is, in order to provide an accurate representation of the percentage of students who had received the opportunity to learn the science, the responses of teachers who taught larger numbers of students were given larger weights than those teachers reporting having fewer students. This weighting provides the most valid measure of this aspect of the intended curriculum.

Display 20 provides summary opportunity-to-learn data for the content necessary to answer the questions grouped by process level. It should be noted that all of the questions in the student assessment section were classified as knowledge, application or higher order skills. This classification is referred to throughout this document as "process level". The levels were described as:

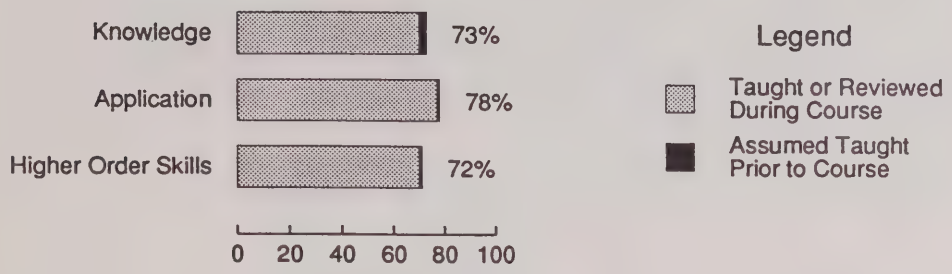
Knowledge - questions that could be answered by recalling factual information.

Application - questions that required application of factual information to new situations.

Display 19
Teachers' Average Report of Percentage of Class Time Spent in Various Instructional Activities
Provincial Results - Physics



Display 20
Percentage of Students Reported by Teachers as Having Had the Opportunity-to-Learn the Science Necessary to Answer the Questions Correctly by Process Level
Provincial Results - Physics



Higher Order Skills - questions that required several reasoning steps and/or the application of concepts from a number of areas of the course.

Display 20 presents average opportunity-to-learn results for the content associated with the questions designated as measuring knowledge, application, or higher-order skills. The bar for knowledge presents average opportunity-to-learn for the content necessary to answer the 29 questions requiring physics knowledge, the bar for application does the same for the 49 questions requiring application skills, and the bar for higher-order skills questions presents the average percentage of opportunity-to-learn for the 22 questions requiring these skills.

One section of each bar represents the percentage of questions for which teachers reported teaching either as new content or reviewing the science necessary to answer the questions. Another section of each bar represents the percentage of questions teachers reported not teaching or reviewing because it was assumed that the science necessary to answer the questions had been taught prior to the course. Overall, the length of the bars represents the percentage of content reported as covered by the teachers.

Question content coverage was greatest for those requiring application skills and least for those requiring higher order skills. Overall the average opportunity-to-learn for all questions was just over 75 percent.

Display 21 provides summary opportunity-to-learn data for the content associated with the questions averaged by the content domain of the questions. The content domains are directly related to the six core units outlined in the old and the new guidelines.

In physics, the content domains and number of questions in each domain were:

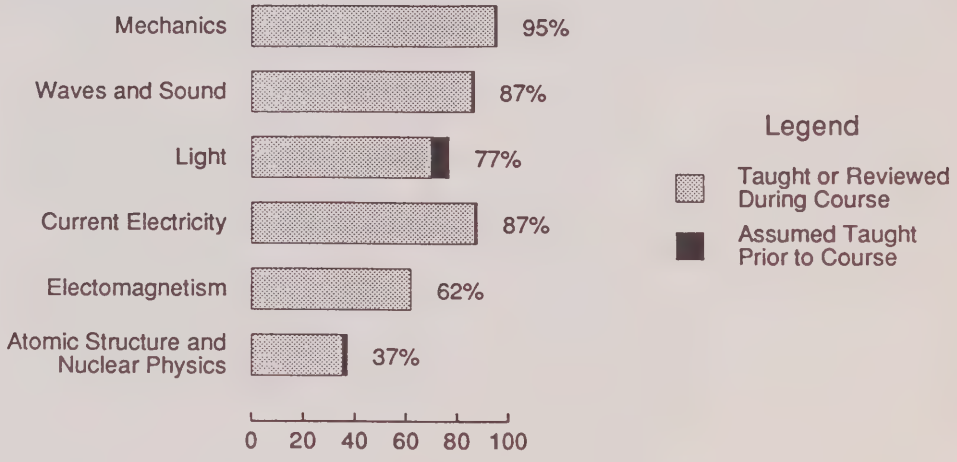
- Mechanics: 20 questions
- Waves and Sound: 14 questions
- Light: 14 questions
- Current Electricity: 17 questions

- Electromagnetism: 21 questions
- Atomic Structure and
- Nuclear Physics 14 questions

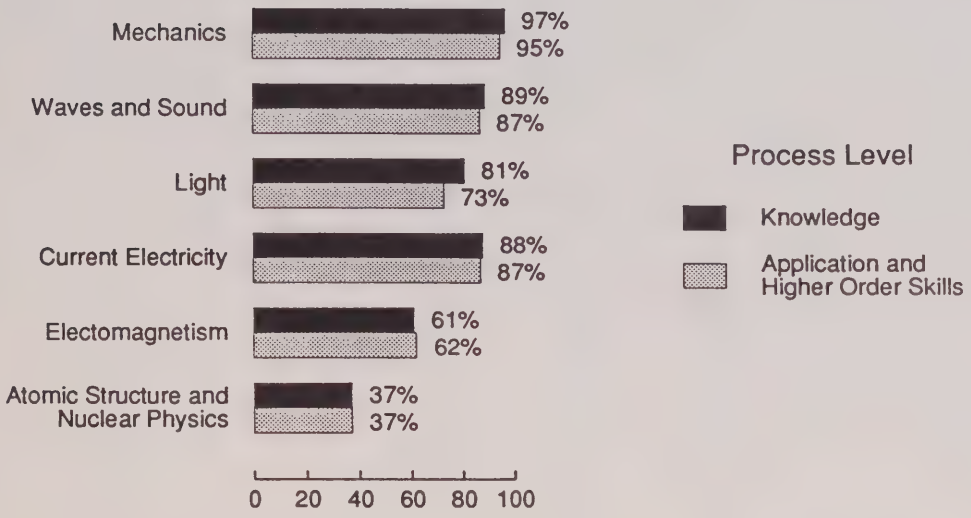
The results in Display 21 present average teacher opportunity-to-learn for the questions in each content domain. The average opportunity-to-learn was clearly highest in Mechanics and lowest in Atomic Structure and Nuclear Physics. Only 35 percent covered the science needed for the questions on Atomic Structure and Nuclear Physics. This is due in part to the timing of the student assessment section of the Provincial Review. Some teachers had yet to cover this section when the assessment was conducted (late May, early June). However, as was noted earlier in the section on **Course of Study Analysis**, many teachers do not include this topic in their courses. Even if "on paper" (in the course of study), this section is often not dealt with to any great extent in the classroom.

Electromagnetism coverage was only about 62 percent. Only one content area was represented by a significant amount of "previously taught" material - the content area "Light", in which just over 7 percent considered that content needed for these questions had been covered prior to this course.

Display 21
Percentage of Students Reported by Teachers as Having Had the Opportunity-to-Learn the Science Necessary to Answer the Questions Correctly by Content Domain
Provincial Results - Physics



Display 22
Percentage of Students Reported by Teachers as Having Had the Opportunity-to-Learn the Science Necessary to Answer the Questions Correctly, by Process Level and Content Domain
Provincial Results - Physics



Display 22 presents similar opportunity-to-learn results, grouped by Knowledge and higher order operations (Application and Higher-Order Skills combined) for each content domain.

Display 23 presents data on opportunity-to-learn for each achievement question. The percentage of teachers in the provincial sample giving each of the response options (Taught or Reviewed, Taught Prior, Taught Later, Not in Curriculum, and Not Taught Other Reasons) is presented for each question.

Displays 24 and 25 provide information concerning the range among schools of reports of student opportunity-to-learn in the province.

Display 23
Percentage of Teachers Indicating Whether the Science Necessary to Answer Each Question Had Been Taught or Reviewed and if Not, the Reason for Not Teaching or Reviewing the Science
Provincial Results - Physics

Mechanics		*Response Categories (Percentage of Teacher Responses)*				
Process Level	*Item No.*	*Taught or Reviewed*	*Taught Prior*	*Taught Later*	*Not in Curriculum*	*Not Taught- Other Reasons*
Knowledge	3	94	1	2	0	3
	61	97	0	1	0	2
	91	98	0	2	0	0
	122	95	0	3	0	2
Application	1	95	0	3	1	1
	2	97	0	2	0	1
	32	95	0	4	0	1
	33	89	2	5	1	4
	62	93	1	2	0	4
	64	99	1	0	0	0
	65	98	0	2	0	0
	92	98	1	2	0	0
	93	94	2	1	0	3
	94	96	0	1	0	3
	123	97	1	1	0	1
	124	93	2	2	0	3
Higher Order Skills	4	87	0	7	1	5
	31	96	0	1	1	2
	63	85	1	2	4	7
	121	97	1	2	0	0

Display 23 (continued)
Percentage of Teachers Indicating Whether the Science Necessary to Answer Each Question Had Been Taught or Reviewed and if Not, the Reason for Not Teaching or Reviewing the Science
Provincial Results - Physics

Waves and Sound / *Process Level*	*Item No.*	*Response Categories (Percentage of Teacher Responses)*				
		Taught or Reviewed	*Taught Prior*	*Taught Later*	*Not in Curriculum*	*Not Taught-Other Reasons*
Knowledge	5	84	1	9	2	5
	34	88	1	8	1	3
	67	92	1	3	1	3
Application	6	77	1	5	4	14
	36	87	1	7	1	4
	37	91	1	5	1	2
	66	83	0	12	1	4
	95	95	2	2	1	1
	96	89	1	3	3	3
	125	86	1	7	4	2
	126	87	3	4	2	5
	127	88	2	4	2	4
Higher Order Skills	35	85	1	10	1	3
	68	74	0	5	9	11

Display 23 (continued)
Percentage of Teachers Indicating Whether the Science Necessary to Answer Each Question Had Been Taught or Reviewed and if Not, the Reason for Not Teaching or Reviewing the Science
Provincial Results - Physics

Light		*Response Categories (Percentage of Teacher Responses)*				
Process Level	*Item No.*	*Taught or Reviewed*	*Taught Prior*	*Taught Later*	*Not in Curriculum*	*Not Taught- Other Reasons*
Knowledge	7	83	4	6	1	6
	38	48	25	4	10	13
	69	85	4	5	1	6
	70	79	6	4	2	8
	98	71	6	5	4	14
	99	60	8	5	10	17
	129	81	6	4	2	7
Application	8	79	7	4	2	8
	71	64	7	6	4	20
	128	83	5	5	1	7
Higher Order Skills	9	35	5	8	23	29
	39	74	6	5	4	11
	97	76	6	4	4	10
	130	56	7	6	13	19

Display 23 (continued)
Percentage of Teachers Indicating Whether the Science Necessary to Answer Each Question Had Been Taught or Reviewed and if Not, the Reason for Not Teaching or Reviewing the Science
Provincial Results - Physics

Current Electricity	*Response Categories (Percentage of Teacher Responses)*					
Process Level	*Item No.*	*Taught or Reviewed*	*Taught Prior*	*Taught Later*	*Not in Curriculum*	*Not Taught- Other Reasons*
Knowledge	12	77	1	5	3	13
	40	92	0	2	0	5
	73	88	0	3	1	8
	101	92	0	2	1	4
Application	10	88	0	4	1	7
	11	90	0	3	1	6
	41	83	1	3	1	11
	43	87	0	3	1	8
	72	90	2	2	1	5
	100	89	1	3	1	6
	102	87	0	3	1	9
	131	89	0	2	1	8
	132	87	0	3	1	10
Higher Order Skills	13	72	1	5	5	16
	42	87	0	3	1	9
	103	88	0	4	1	8
	133	86	0	3	1	9

Display 23 (continued)
Percentage of Teachers Indicating Whether the Science Necessary to Answer Each Question Had Been Taught or Reviewed and if Not, the Reason for Not Teaching or Reviewing the Science
Provincial Results - Physics

Electro-Magnetism		*Response Categories (Percentage of Teacher Responses)*				
Process Level	*Item No.*	*Taught or Reviewed*	*Taught Prior*	*Taught Later*	*Not in Curriculum*	*Not Taught-Other Reasons*
Knowledge	17	62	0	9	4	25
	45	59	1	5	8	26
	105	70	0	6	6	18
	137	53	0	9	7	31
Application	14	59	0	8	6	26
	15	74	0	6	5	15
	44	71	0	7	4	18
	46	63	0	8	5	24
	74	68	0	7	6	20
	75	66	0	7	6	22
	106	50	0	9	9	32
	107	71	0	6	4	19
	134	73	1	6	5	15
	136	54	0	8	8	30
Higher Order Skills	16	62	0	9	5	24
	47	50	0	12	5	33
	76	46	0	10	12	31
	77	56	0	8	7	30
	104	73	0	5	5	17
	108	57	0	8	8	27
	135	58	0	10	7	25

Display 23 (continued)
Percentage of Teachers Indicating Whether the Science Necessary to Answer Each Question Had Been Taught or Reviewed and if Not, the Reason for Not Teaching or Reviewing the Science
Provincial Results - Physics

Atomic Structure and Nuclear Physics *Process Level*	*Item No.*	*Response Categories (Percentage of Teacher Responses)* *Taught or Reviewed*	*Taught Prior*	*Taught Later*	*Not in Curriculum*	*Not Taught-Other Reasons*
Knowledge	19	32	3	19	11	36
	50	39	0	15	13	33
	79	31	2	18	8	41
	109	40	1	16	8	35
	138	34	1	18	10	37
	140	37	1	20	8	35
Application	18	37	2	18	9	34
	20	14	0	18	19	48
	48	43	12	15	5	25
	49	37	1	17	11	34
	78	35	1	17	11	36
	80	34	1	18	9	38
	139	38	1	20	8	33
Higher Order Skills	110	42	2	17	8	32

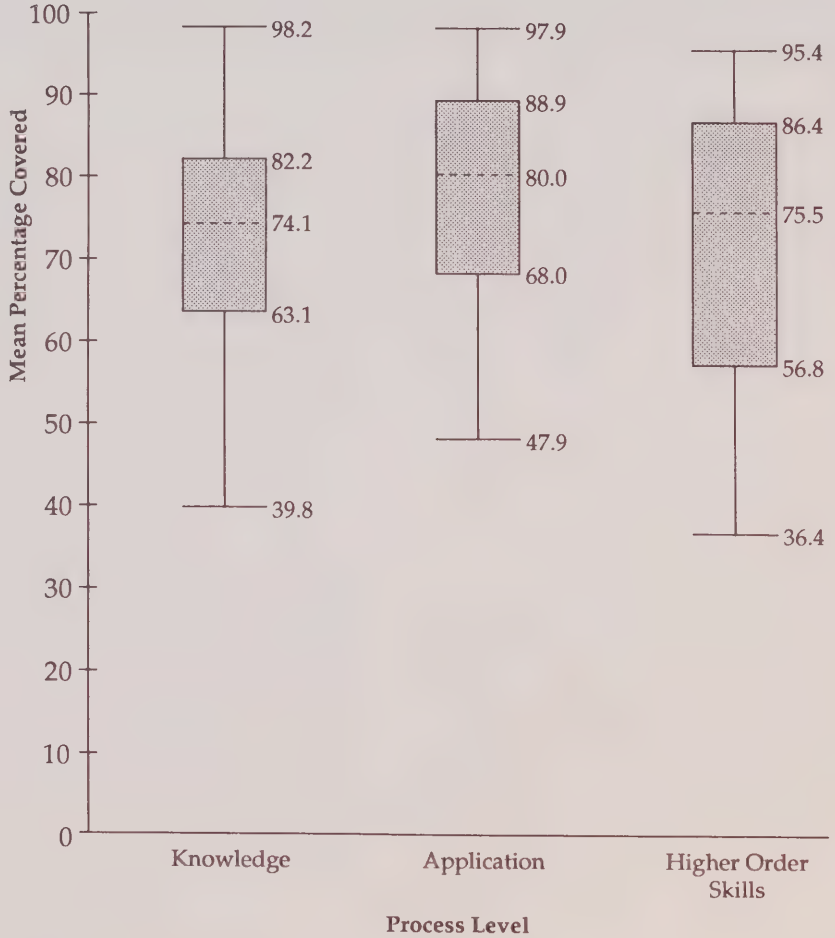
8.4 Teachers' Use Of Teaching Resources

Teachers indicated the frequency of use of various teaching resources. A wide range of resources are available to science teachers including textbooks and reference books, guest speakers, computers, OAIP materials and locally produced equipment and teaching materials. The percentage of teachers indicating frequency of use of these resources is presented in Display 26.

Almost all teachers regularly use textbooks and reference books along with the chalkboard and overhead projectuals. Commercially produced

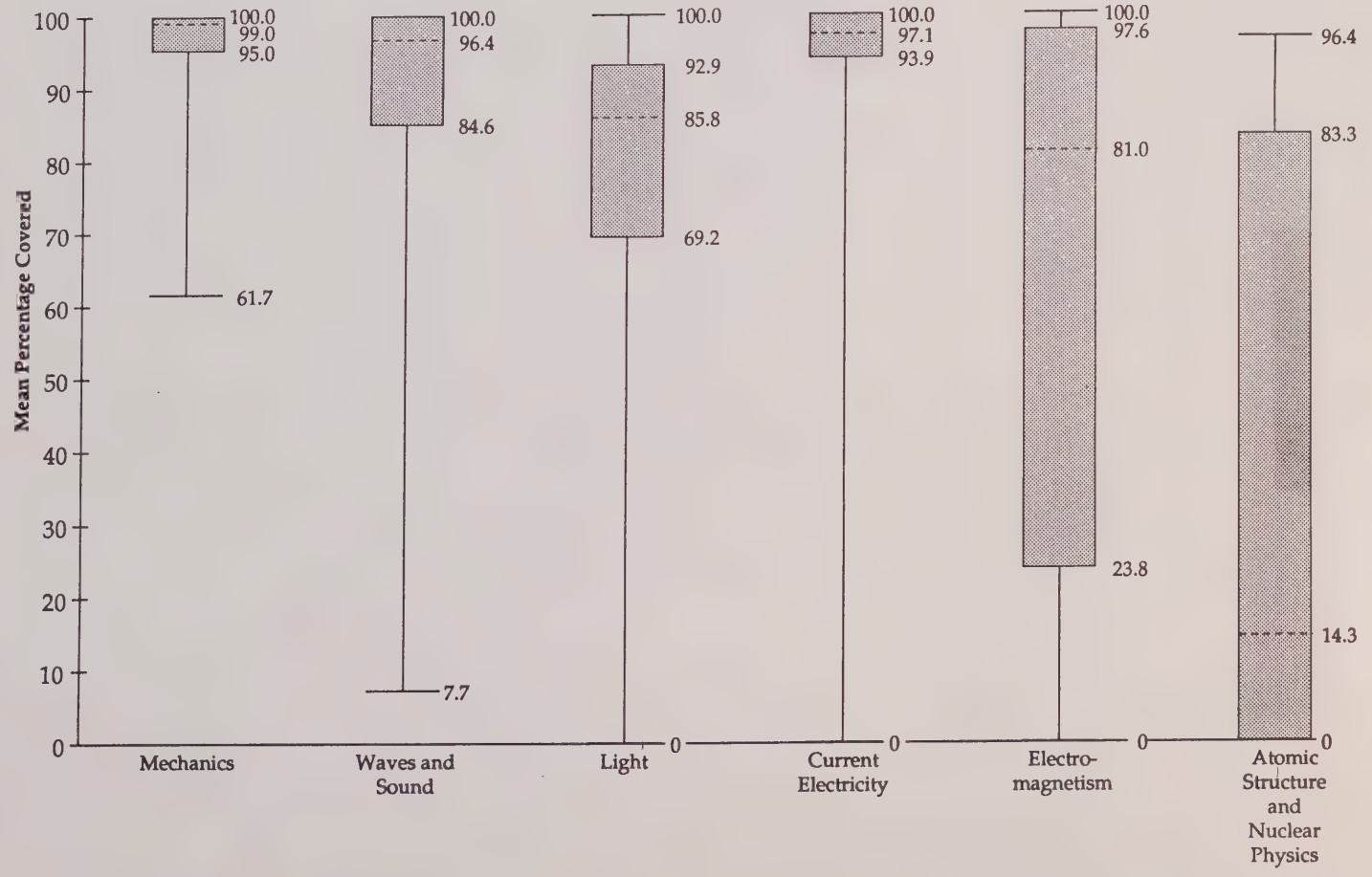
Display 24

Variation Among Schools in Average Student Opportunity-to-Learn: Questions Grouped by Process Level



Display 25

Variation Among Schools in Average Student Opportunity-to-Learn: Questions Grouped by Content Domain



science apparatus and equipment is also used by most teachers. Only one quarter of the teachers use OAIP materials regularly while one teacher in five never uses them. Almost two-thirds never use computer software as a teaching resource. Less than 10 percent use library books, journals and magazines with any frequency.

8.5 Instructional Approaches

Ten general approaches to classroom instruction were presented and teachers were asked to indicate their frequency of use of each. These approaches are well known among science teachers in general and physics teachers in particular, and

Display 26
Percentage of Teachers Reporting Varying Frequency of Use of Teaching Resources
Provincial Results - Physics

Teaching Resources	*Frequency of Use*			
	Not At All	*Occas-ionally*	*Frequ-ently*	*Always*
Textbooks and Reference Books	1	5	51	44
Library Books, Journals, and Magazines	14	78	8	0
Workbooks	75	13	8	5
Laboratory Worksheets	6	45	45	5
Science-Related Computer Software	62	35	2	1
Videotapes, Audiotapes, TVO	8	81	11	0
Field Trips	61	38	1	0
Guest Speakers	62	38	0	0
Films, Slides, and Filmstrips	7	78	15	1
Blackboards, Overhead Projectuals	0	10	51	40
OAIP Materials	20	54	21	5
Commercially Produced Science Apparatus/Equipment	1	20	62	17
Locally Produced Science Apparatus/Equipment	21	60	18	1
Locally Produced Teaching Materials	15	44	34	7

Display 27
Percentage of Teachers Reporting Varying Frequency of Use of Teaching Approaches
Provincial Results - Physics

Instructional Approach	*Frequency of Use*			
	Not At All	*Occas-ionally*	*Frequ-ently*	*Always*
Class Instruction	6	26	63	5
Group Instruction	11	59	29	0
Individualized Instruction	50	43	7	0
Textbook	11	64	25	0
Socratic	1	24	67	9
Demonstration	0	57	41	1
Guided Discovery	12	60	27	1
Laboratory	0	28	66	6
Project	29	65	5	1
Science Kit	74	25	2	0

are presented in Display 27. About two-thirds of the teachers frequently use the socratic approach, laboratory activities and lectures. Projects and individualized instruction are used infrequently. In fact, half of the teachers never provide individualized instruction. Most teachers reported that they do not use science kits in their classrooms.

8.6 Teachers, Students and Evaluation

A series of questions were asked of teachers to determine their purposes in evaluating students, their approaches towards evaluation, and their use of various evaluation methods.

Evaluation can be undertaken for three main purposes. Diagnostic evaluation is undertaken to identify individual student strengths and weaknesses and identify appropriate remedial measures. Formative evaluation provides a basis for the modification of instruction and the identification of areas of class weakness. Summative evaluation serves to identify end-of-unit or end-of-course achievement levels. Display 28 presents teachers' reports of their frequency of use of each of these three purposes of evaluation. Summative evaluation is clearly the most common type used while diagnostic evaluation is used the least.

Display 28
Percentage of Teachers Reporting Varying Frequency of Evaluation for Diagnostic, Formative, and Summative Purposes
Provincial Results - Physics

Evaluation Purpose	*Frequency of Use*			
	Not At All	*Occas-ionally*	*Frequ-ently*	*Always*
Diagnostic	20	63	15	3
Formative	8	53	33	6
Summative	1	2	44	53

Display 29
Percentage of Teachers Reporting Varying Emphasis Upon Norm-Referenced, Criterion-Referenced, Individualized Ability, and Growth-Based Approaches to Evaluation
Provincial Results - Physics

Evaluation Approach	*Emphasis Placed on Approach*			
	None	*Some*	*Moder-ate*	*Strong*
Norm-Referenced	26	40	24	11
Criterion-Referenced	3	13	46	38
Individualized Ability	25	40	27	8
Growth-Based	38	49	12	1

Four different approaches to evaluation can be identified. While these approaches share some obvious relationship to the purposes of evaluation, there is some value to examining them independently.

Norm-reference approaches to evaluation attempt to identify levels of performance by spreading students out and using comparative criteria in assigning marks or grades.

Criterion-referenced approaches are more concerned with identifying areas where instruction has been effective and assessing areas of student weakness.

Individualized-ability approaches to evaluation assist in the assignment of marks or grades through comparison of each student's performance with his or her hypothesized ability in the subject area.

Growth-based approaches focus upon the amount of improvement in performance students have made rather than their absolute level of performance. Use of this approach often involves pre-test and post-test situations to provide the comparison and identify the level of improvement.

Display 29 shows the approaches teachers report using in their evaluation of students. Most teachers place the greatest emphasis on criterion-referenced evaluation and the least on growth-based. Over one-third place moderate or strong emphasis on norm-referenced evaluation.

Display 30 describes teachers' reports of the actual methods used in the evaluation of students. A wide range of methods are available to all teachers. Traditional methods tend to dominate. Unit tests are most common and three-quarters of the teachers give examinations regularly. Laboratory reports are also important and widely used by physics teachers. All other methods such as peer evaluation and observation, are used only occasionally or not at all by the majority of the teachers.

A final summary of the approaches teachers use towards evaluation of students is presented in Display 31. In this display is the average of the relative weights assigned to various broad evaluation categories for awarding students' final grades. The four broad categories included:

- tests,
- examinations,
- observation (lab techniques, participation), and
- product analysis (notebooks, reports, projects).

Tests and examinations each make up over one-third of student final grades. Product analysis involving notebooks, reports and projects contribute 15 percent of the final mark. The examination and product analysis values are generally consistent with the mandatory allotments for these components in the new guideline.

8.7 Classroom Use of Calculators and Computers

Display 32 is a summary of the amount of student use of calculators and computers in the classroom as reported by the teachers. Calculators are used regularly in class by most students, especially for activities involving problem solving, while computers are rarely or never used.

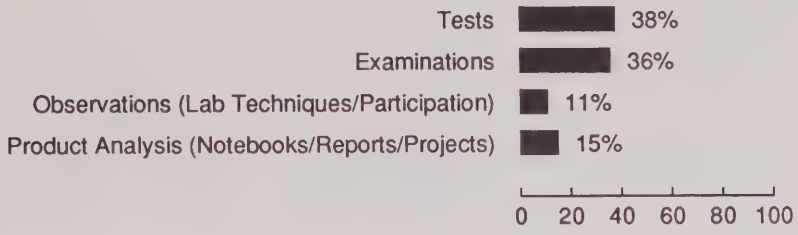
8.8 Student Homework

Display 33 summarizes the amount of homework assigned by teachers of the Advanced Level Senior Division Physics course. Although the amount assigned varies considerably, almost a third of the teachers assign 5 hours of homework per week. It is of interest to note that almost 60 percent of the students reported doing up to 2 hours of science homework per week.

Display 30
Percentage of Teachers Reporting Varying Frequency of Use of Various Evaluation Methods
Provincial Results - Physics

Evaluation Methods	*Frequency of Use*			
	Not At All	*Occas-ionally*	*Frequ-ently*	*Always*
Homework	4	53	35	8
Anecdotal Records	52	40	7	1
Performance of Lab Skills	6	60	32	3
Lab Writeups	0	33	58	9
Science Notes	47	41	10	2
Problem Worksheets	10	55	31	5
Oral Presentations	52	44	4	0
Oral Tests	83	15	2	0
Quizzes (based on one lesson or topic)	8	51	31	9
Tests (based on one unit)	1	1	49	49
Examinations (based on more than one unit)	1	24	28	47
Individual Contracts	81	18	1	0
Student Interviews	79	19	2	0
Peer Evaluation	75	25	0	0
OAIP Questions	23	49	23	5
Local Standardized Tests	83	10	7	1
Commercial Standardized Tests	80	18	3	0
Reports	16	66	16	2
Projects	27	64	8	1
Major Assignments	26	60	13	1
Behaviours and Attitudes	35	54	8	3
Attendance	45	44	5	6
Participation	27	55	12	6
Other	96	3	1	0

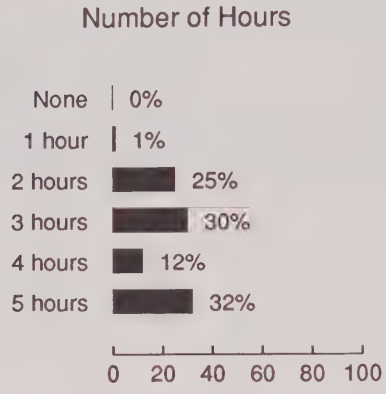
Display 31
Proportional Weights Assigned to Various Evaluation Practices by Teachers for Assigning Students' Final Grades
Provincial Results - Physics



Display 32
Percentage of Teachers Reporting Varying Student Classroom Use of Calculators and Computers
Provincial Results - Physics

Level of Student Use	*Calculators*	*Computers*
Not At All	0	62
Rarely	0	25
Occasionally	3	10
Frequently	55	2
Always	43	0

Display 33
Percentage of Teachers Reporting Varying Amounts of Homework Assigned Each Week
Provincial Results - Physics



8.9 The Teaching of the Experimental Method in Physics Courses

For the purposes of this review, the term "Experimental Method" is used to describe a method of asking questions and solving problems that many might refer to as the "Scientific Method". The teaching of the experimental method was seen as a window into the specific instructional and evaluation approaches used to transmit physics content and skills. Inquiries were made into the frequency of instruction focussed upon various aspects of the experimental method and the importance placed upon learning objectives associated with the experimental method.

Display 34 presents the frequency of student activities concerned with experimentation. Students most frequently carry out experiments using a worksheet or lab manual where information and instructions are provided. However, over half of the teachers do have students design experiments, but only occasionally. Complete experiments are usually conducted as opposed to having students do only one part of the experimental procedure. It is also relatively common to have students observe experiments carried out by the teacher.

Display 35 displays the frequency of instruction focussed upon aspects of the experimental method. Most teachers teach some specific lessons intended to improve students' ability to do the various steps in an experiment. The emphasis is most often on the collection and analysis of data drawing conclusions, making generalizations and writing reports. Less emphasis is placed on the initial activities of stating hypotheses and experimental design.

Display 34
Percentage of Teachers Reporting Varying Frequency of Student Activities During the Course Concerned with the Experimental Model
Provincial Results - Physics

Student Activities	*Frequency of Activities*			
	Never	*1-3 Times*	*4-8 Times*	*> 8 Times*
Observe the Teacher Doing an Experiment	4	40	39	17
Carry Out an Experiment Using a Worksheet Lab Manual that Gives Specific Purpose, Apparatus, Method, etc.	2	7	28	63
Design and Carry Out an Experiment on their Own on a Topic Chosen by the Teacher	39	51	9	2
Design and Carry Out an Experiment on their Own on a Topic of their Own Choosing	70	31	0	0
Create a Question or Hypothesis to be Investigated, but NOT Carry Out the Experiment	48	46	6	0
Design an Experiment - Identify Variables to be Measured, Held Constant, etc. - but NOT Carry Out the Experiment	52	43	5	1
Collect Data and Record Data Without Doing the Rest of the Steps in an Experiment	63	31	5	1
Analyze Data - Without Doing the Other Parts of the Experiment	20	58	19	3
Draw Conclusions from Data - Without Doing the Other Parts of the Experiment	19	63	16	3
Make Generalizations from Experimental Results - Without Carrying Out the Whole Experiment	20	61	17	2
Prepare a Report Based on the Results of an Experiment Done by the Teacher or Others	42	44	11	3

Display 35
Percentage of Teachers Reporting Varying Frequency of Instruction Focussed Upon Components of the Experimental Method
Provincial Results - Physics

Components of Experimental Method	*Frequency of Instruction*			
	Never	*1-3 Times*	*4-8 Times*	*> 8 Times*
State Hypotheses or Ask Questions in a More Scientific Way	23	54	16	8
Design Experiments - Identify Variables and Plan Procedures to Collect Data	22	59	15	4
Collect Reliable, Relevant Data	10	48	22	20
Analyze Data	3	41	27	28
Draw Conclusions	8	45	21	26
Make Generalizations	9	44	24	23
Write Reports	8	52	18	21

Display 36 describes the importance placed upon learning objectives concerned with the experimental method. The most significant objective for students to achieve is learning to analyze data. Many teachers also place great importance on students learning the process for application to other aspects of life. It is encouraging to note that more teachers feel that experiments should be used to discover laws and principles rather than to verify them. The importance placed on demonstrating practical applications is consistent with the spirit of the new guideline.

8.10 The Concept of Work - Teaching and Evaluation

To gather specific information on how teachers instruct and evaluate the learning of specific physics laws and concepts, the concept of "work" was chosen as an illustrative topic. The possible strategies that could be used to teach and evaluate student learning of the concept of work were presented to teachers. Display 37 presents data on teachers' use of various teaching strategies for this

concept and Display 38 shows the strategies teachers used for assessing student understanding of the concept.

Teachers use a combination of strategies in presenting the concept of work. The frequency of reported use of specific strategies provides an interesting sequence from active to passive roles for students - to determine how students visualize the concept and to guide them to an improved understanding, to give examples of when work is done and not done (concept clarification), to state the definition and then read about work in the text. Reading followed by small group discussion is rarely used.

Teachers evaluate the students' learning of the concept of work in various ways. All teachers ask students to apply their understanding of the concept to solve problems.

Display 36
Percentage of Teachers Placing Varying Levels of Importance Upon Various Learning Objectives Concerned with the Experimental Method
Provincial Results - Physics

Objectives of the Experimental Method	*Level of Importance*		
	None	*Some*	*Great*
Discover Laws and Principles Before Being Taught by Teacher	4	52	44
Verify Laws and Principles After Being Taught by Teacher	5	59	37
Provide Opportunities for Discussions of the Role of Science in Society	6	63	31
Demonstrate Technological Processes	10	75	16
Demonstrate Practical Applications	3	53	45
Learn to Analyze Data	1	22	77
Learn the Process of Experimentation for Application to Other Aspects of Life	5	40	56
Other	94	1	5

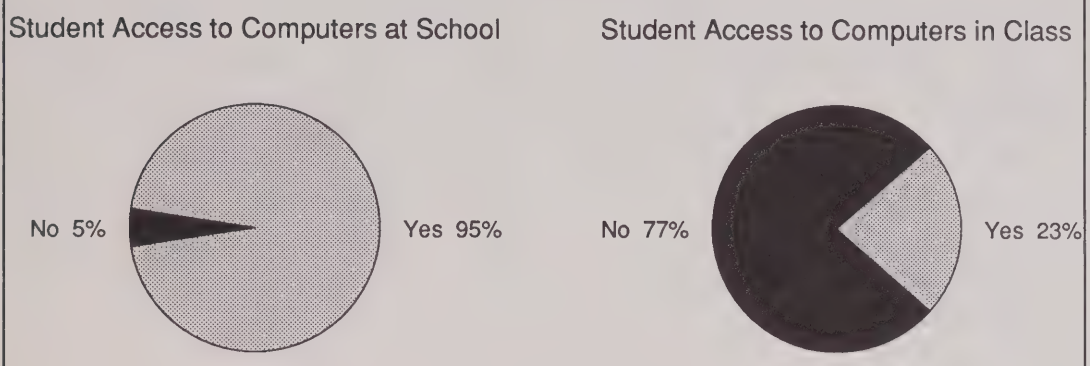
Display 37
Percentage of Teachers Reporting Use of Various Strategies for Teaching the Concept of Work
Provincial Results - Physics

Teaching Strategies for the Scientific Concept	*Reporting Use*	
	Yes	*No*
State the Definition for Students	76	25
Give Students Examples When Work is Done and When Work is Not Done and Ask Them to State the Definition	86	14
Have Students Read the Section of the Text on the Concept of Work	62	38
Have Students Read the Text and Then Discuss the Concept of Work in Small Groups	10	90
Question the Students to Determine Their Idea of What Work is and Guide Them to an Improved Definition	89	11
Other	12	88

Display 38
Percentage of Teachers Reporting Use of Various Evaluation Techniques for Assessing Students' Learning of the Concept of Work
Provincial Results - Physics

Evaluation Technique	*Reporting Use*	
	Yes	*No*
Ask Students to Define the Concept	88	12
Ask Students to Give Examples of the Concept	96	4
Ask Students to Distinguish Between Examples and Non-Examples of the Concept	88	12
Ask Students to Describe Applications of the Concept	89	11
Ask Students to Solve Problems Using the Concept	100	0
Other	6	94

Display 39
Percentage of Teachers Reporting Student Access to Computers in the School and in the Classroom
Provincial Results - Physics



9. Computers in the Classroom

This section reports upon the availability and use of computer hardware and software generally in the school and specifically in the physics classroom.

Display 39 presents teacher reports of the degree of student access to computers generally in the school and specifically in the physics classroom while Display 40 shows the different uses that teachers make of computer programs in the classroom.

Although almost all teachers report that students have access to computers at school less than one-quarter report student access to computers in class. These data are generally consistent with student reports which indicated that a little over one-third ever use a computer at school. Computers are in the school usually in computer laboratories, but not in the physics classroom.

Most types of computer programs are used in only a small number of classrooms. Commercial software programs are receiving the greatest use. However, even these are not used regularly.

The Ministry of Education provides a number of software programs for instructional use through the Ontario Educational Software Service. Inquiry was made of teachers concerning the availability and use of these programs. Display 41 presents these results.

Most teachers do not have Ontario Educational Software Services programs available for student use. The one most available is a chemistry

Display 40
Percentage of Teachers Reporting Varying Use of Computer Programs in the Classroom
Provincial Results - Physics

Various Uses of Computer Programs	*Used*		*Frequency of Use*		
	Yes	*No*	*Rarely*	*Some-times*	*Often*
Spreadsheets	4	96	67	22	11
Wordprocessing	8	92	44	44	13
Database	5	95	60	40	0
OESS Programs (Ontario Educational Software Service)	9	91	57	36	7
Commercial Software Programs	17	83	48	37	15

Display 41
Percentage of Teachers Reporting The Availability and Amount of Use of Various Ontario Educational Software Service Programs
Provincial Results - Physics

Ontario Educational Software Service Programs	*Availability*		*Amount of Use*			
	Yes	*No*	*None*	*Rarely*	*Some-times*	*Often*
Logic Gates	11	89	98	1	2	0
Logic Lab	11	89	98	2	1	0
Ideal Gas Simulation	16	84	95	3	2	0
Let There Be Light	6	94	98	1	1	0
Watfile Plus	15	85	98	1	1	0
Electric Chemistry Building	20	80	94	3	3	0
Flamelife	13	87	96	3	1	0

Display 42
Percentage of Teachers Reporting Various Sources Of Their Training in Instructional Use of Computers and Hours Received in Such Training
Provincial Results - Physics

Training Source	*Training Received*		*Average Number of Hours*
	Yes	*No*	
School-Based (e.g. other teachers)	26	74	2.1
Board-Based (e.g. special course)	17	83	2.1
Commercial Training	0	100	0.0
Professionally-Based (e.g. previous employment)	2	98	0.3
University-Based (e.g. Faculty of Education, OISE)	20	80	3.5
Self-Taught	39	61	4.1
Other	5	95	1.1

program. Even when the programs are available, student use is minimal.

Display 42 shows the percentage of teachers who have received training in the instructional use of computers and if so, the average number of hours of training received in various settings. Teachers are mostly self-taught in the use of computers. In all cases the number of hours of training is minimal.

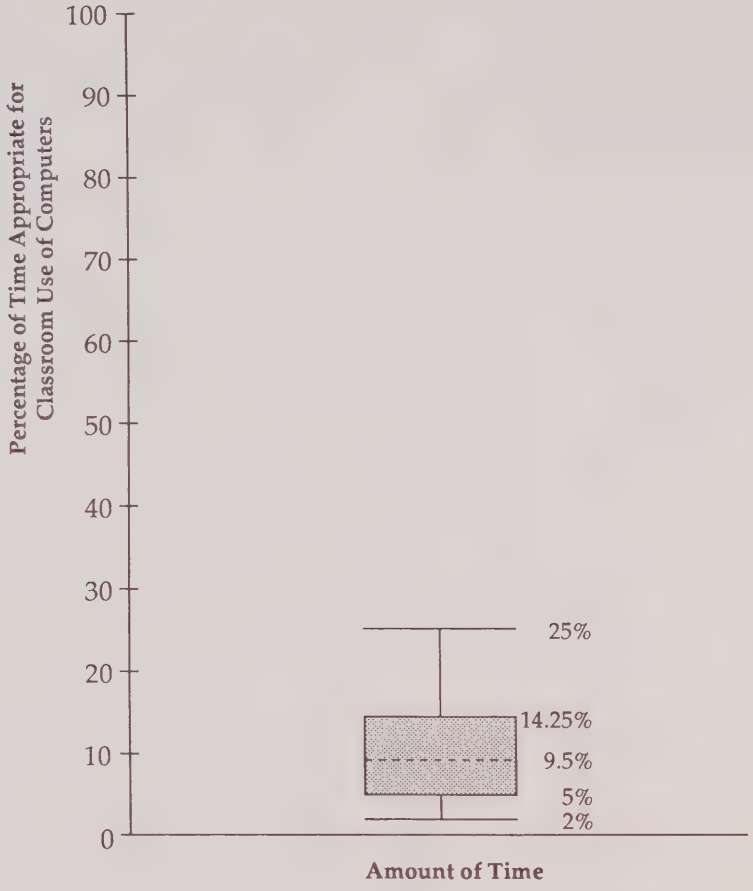
Finally, teachers were asked the following question: "What percent of physics classroom time do you feel computer programs could be effectively used, if the proper software were available?" Display 43 describes the range seen among teachers in the province to this question.

10. The Attained Curriculum

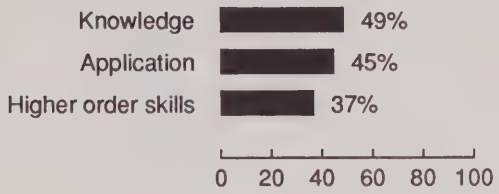
Student achievement was assessed by means of 100 selected response questions and five extended-response questions selected by a team of Ontario physics educators. The questions were placed into five separate student assessment booklets each containing 20 selected-response questionand one extended-response question. Each student responded to only one booklet. Student attitudes were assessed using a similar procedure. Each student responded to a series of questions placed at the end of each booklet. All of the questions in the

Display 43

Reports of the Percentage of Time That Would Be Appropriate for Classroom Use of Computers if the Appropriate Software was Available



Display 44
Percentage of Students Answering the Questions Correctly
by Process Level
Provincial Results - Physics



student assessment booklets were related to the six content domain areas selected for the review and were also classified as to process level (knowledge, application, or higher-order skills). The proportion of questions in each content domain was determined by the time allotment indicated for each in the existing guideline Curriculum S-17A. Questions were deliberately selected to make applications the dominant process level. Each booklet contained a mixture of questions from each content domain and the various process levels.

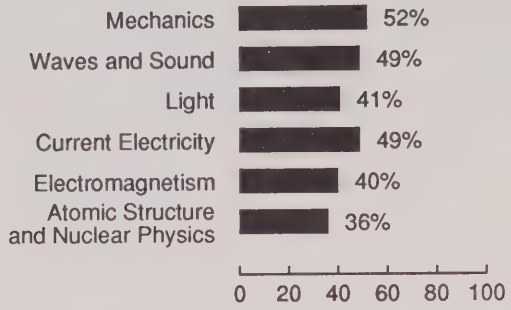
10.1 Selected Response Questions

The results are presented in a format similar to the student opportunity-to-learn information. Three graphs provide summary data on student achievement, followed by a table presenting student results question by question. These results, both graphic and tabular,also are presented in school and board reports with the appropriate level of data.

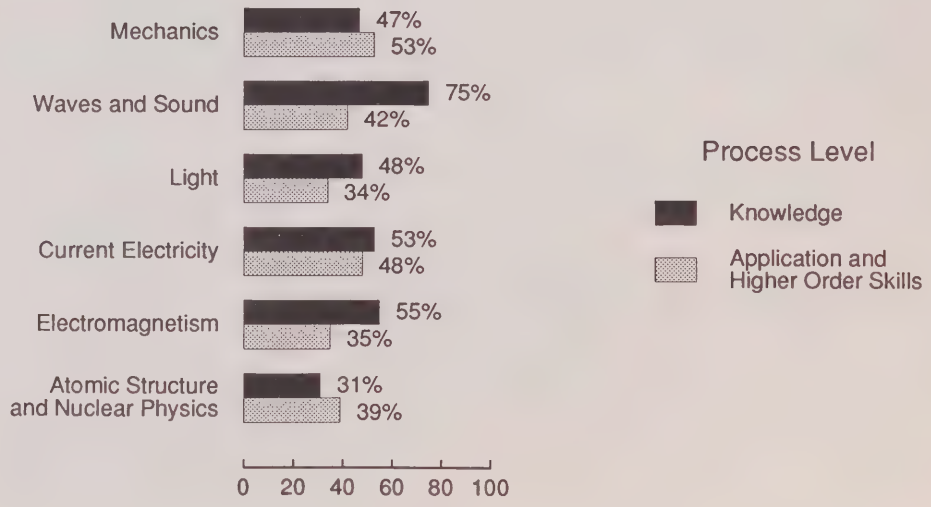
Display 44 shows the percentage of students who answered the questions correctly by process level. This display provides a summary of levels of student achievement presenting average student achievement for questions designed to measure knowledge, application, or higher-order skills. The bar for knowledge presents average percentage of students answering correctly the 29 questions which were seen as requiring physics knowledge, the bar for application does the same for the 49 questions requiring application skills, and the bar for higher-order skill questions presents the average percentage of students correct for the 22 questions requiring these skills in order to elicit a correct response.

Display 45 presents the mean percentage of students correctly answering the questions found in each content domain. Mechanics, waves and sound and current electricity are clearly the content domains where students were most successful. The levels of achievement in each content domain correlate directly with the student opportunity-to-learn data (see Display 21). In addition, the topic of electromagnetism involves topics which are theoretical and somewhat abstract. The unit on Atomic Structure and Nuclear Physics, which is the last unit covered, would be only partially completed in most schools when the student achievement assessment was done.

Display 45
Percentage of Students Answering the Questions Correctly
by Content Domain
Provincial Results - Physics



Display 46
Percentage of Students Answering the Questions Correctly
by Process Level and Content Domain
Provincial Results - Physics



In examining the average percentage correct for each domain it should be noted that the items in the Ontario Assessment Instrument Pool in physics are rated according to difficulty level. The majority are rated as difficult items. Of the items included in the student achievement booklets in this review 7 were rated as easy, 24 were rated as of medium difficulty and 58 were rated as difficult.

Display 46 presents similar results but in this case, questions were grouped by both process level - lower (knowledge) and higher (application and higher-order skills) - and content domain. The top set of bars represent the percentage of students responding correctly to the mechanics questions grouped by lower and higher process question level. The remaining double bar graphs illustrate the same information for the other content domains grouped by process level.

Displays 47 and 48 provide information concerning the range among schools in student achievement in the province using box and whiskers charts.

The previous displays detailed student achievement by process level, content domain, and a combination of the two in one display (Display 46). This section provides achievement information at the individual question level.

For example, the twenty questions for Mechanics have been grouped together and are identified by process level. Questions (from the Student Assessment Booklets) 3, 61, 91, 122 were chosen as knowledge questions; questions 1, 2, 32, 33, 62, 64, 65, 92, 93, 94, 123, and 124 as applications questions; and questions 4, 31, 63, and 121 are seen as higher-order skills questions. A similar procedure has been used for the questions in the other content domain areas.

- For each question, the following is provided:
- the predicted percentage correct (by teachers);
- the answer key;
- the distribution of student choices (by percentage);
- the total number of omissions.

In general, teachers tended to overestimate student achievement. Predictions for two-thirds of the questions were higher than the actual percentage correct. Overestimations were most common in Mechanics, Light and Current Electricity. In both Mechanics and Electromagnetism half of these predictions were high by more than 15 percent. In the process levels the results for application questions were overestimated most and higher order ones least.

Of the 100 selected-response questions used in the review, 74 were used in the 1983 Field Trials of OAIP Physics instruments. The results of this review were compared with those reported in the *Report of the Field Trials in Physics... Senior Division*. It is significant to note that performance on this provincial review was better on 61 of the items, poorer on 6 and unchanged for the remaining 7.

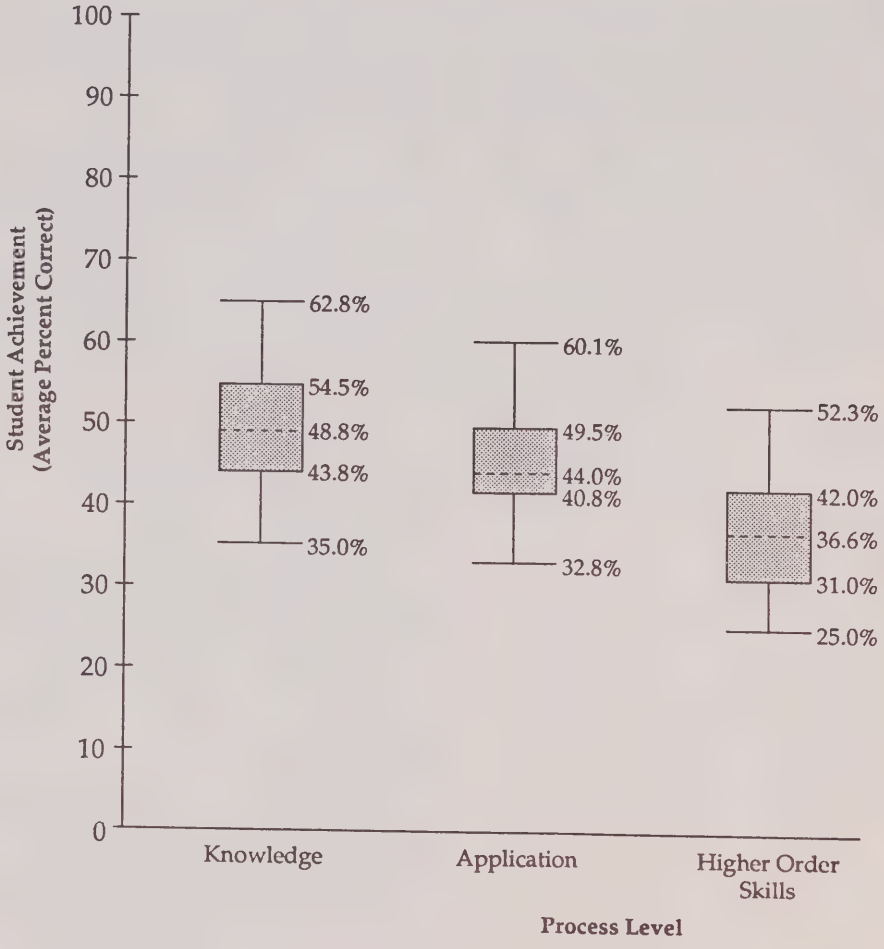
10.2 Extended Response Questions

The Ministry has produced *A Guide for Scoring the Extended Response Questions in the Physics Provincial Review* which contains the scoring criteria which were used. School boards have been provided with this guide to analyze student responses from schools which were not part of the provincial sample.

The extended-response questions were designed to indicate student achievement along a number of dimensions, each of which forms a part of the Senior Division Advanced Level Physics course. Three of the questions (those in booklets 2,3,and 4) dealt with drawing and labelling a diagram in different contexts. The questions in booklets 3 and 4 required the solution of numerical problems; those in booklets 1 and 2 involved the interpretation of data. Question 5 asked students

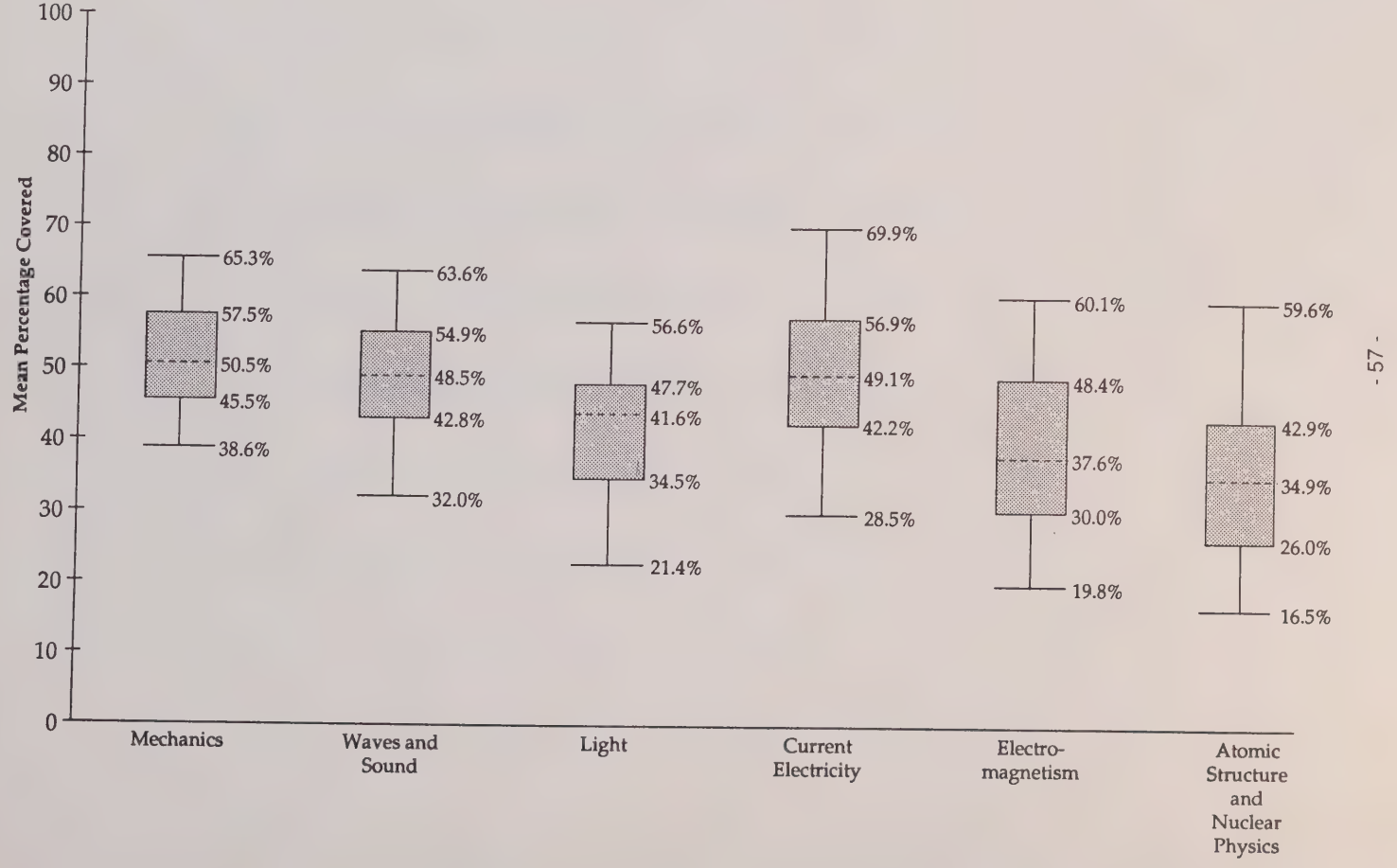
Display 47 Subject: Physics

Variation Among Schools in Average Student Achievement: Questions Grouped by Process Level



Display 48

Variation Among Schools in Average Student Achievement: Questions Grouped by Content Domain



Display 49
Detailed Item Analysis for Student Achievement Questions
Provincial Results - Physics

Mechanics		*Teacher Predicted*		*Student Choices (%)*					
Process Level	*Item No.*	*Correct (%)*	*Key*	*A*	*B*	*C*	*D*	*E*	*Omits*
Knowledge	3	64	D	4	1	6	44	45	0
	61	74	B	20	58	8	6	7	0
	91	70	D	29	5	2	54	9	1
	122	54	B	13	32	13	39	2	1
Application	1	63	A	49	23	2	16	8	1
	2	67	B	4	45	7	4	38	2
	32	55	E	15	22	30	7	26	1
	33	53	C	10	18	42	15	11	3
	62	68	D	6	50	4	34	5	1
	64	71	C	1	1	92	2	3	0
	65	63	C	7	23	64	5	1	0
	92	63	D	23	4	4	50	18	1
	93	65	E	9	6	4	26	53	2
	94	60	C	2	3	73	2	20	1
	123	74	E	8	2	16	5	69	1
	124	59	A	48	16	23	6	6	1
Higher Order Skills	4	42	E	6	14	53	5	17	5
	31	66	A	63	1	1	5	29	0
	63	46	B	5	59	8	25	2	0
	121	64	B	3	63	18	7	9	1

Display 49 (continued)
Detailed Item Analysis for Student Achievement Questions
Provincial Results - Physics

Waves and Sound / *Process Level*	*Item No.*	*Teacher Predicted Correct (%)*	*Key*	*Student Choices (%)*					
				A	*B*	*C*	*D*	*E*	*Omits*
Knowledge	5	62	A	76	7	5	9	4	1
	34	54	E	7	9	12	13	57	1
	67	74	A	91	1	3	1	4	1
Application	6	53	B	3	64	5	20	6	1
	36	48	A	19	23	16	4	37	1
	37	55	C	4	3	72	12	7	2
	66	52	B	4	59	7	8	20	1
	95	69	B	9	31	37	19	4	1
	96	40	D	33	16	11	22	16	3
	125	55	B	24	57	6	10	3	1
	126	46	B	4	32	7	6	50	1
	127	53	B	10	42	10	4	32	2
Higher Order Skills	35	46	D	1	30	3	45	20	1
	68	36	C	8	54	14	8	14	1

Display 49 (continued)
Detailed Item Analysis for Student Achievement Questions
Provincial Results - Physics

Light

Process Level	*Item No.*	*Teacher Predicted Correct (%)*	*Key*	*Student Choices (%)*					
				A	*B*	*C*	*D*	*E*	*Omits*
Knowledge	7	67	A	58	4	30	3	4	1
	38	46	C	22	7	39	10	21	1
	69	73	A	79	8	3	3	6	1
	70	53	D	19	14	9	46	10	2
	98	48	E	16	27	20	15	21	1
	99	49	B	14	47	11	22	5	1
	129	51	B	12	48	15	15	7	3
Application	8	55	D	13	8	18	48	12	2
	71	36	C	16	22	31	16	13	1
	128	57	E	12	7	28	22	32	0
Higher Order Skills	9	23	C	15	13	29	13	24	6
	39	45	A	35	14	17	15	19	1
	97	38	B	14	27	28	22	8	2
	130	34	D	10	18	15	36	20	2

Display 49 (continued)
Detailed Item Analysis for Student Achievement Questions
Provincial Results - Physics

Current Electricity *Process Level*	*Item No.*	*Teacher Predicted Correct (%)*	*Key*	*Student Choices (%)* *A*	*B*	*C*	*D*	*E*	*Omits*
Knowledge	12	56	A	55	3	6	2	31	3
	40	57	C	21	30	40	1	7	1
	73	59	B	9	58	16	9	7	2
	101	68	D	11	4	15	58	11	1
Application	10	64	D	22	4	3	63	6	2
	11	69	D	9	3	17	66	1	4
	41	49	A	40	7	26	17	7	3
	43	59	A	51	22	7	11	9	2
	72	58	C	40	7	46	3	4	2
	100	53	D	13	38	9	33	3	3
	102	63	D	31	6	8	41	12	2
	131	64	B	9	75	5	2	8	1
	132	62	B	12	62	10	4	10	1
Higher Order Skills	13	41	B	18	41	21	13	3	5
	42	45	C	10	7	57	16	7	3
	103	45	D	2	52	13	27	4	2
	133	48	B	33	28	24	5	8	1

Display 49 (continued)
Detailed Item Analysis for Student Achievement Questions
Provincial Results - Physics

Electro-Magnetism Process Level	Item No.	Teacher Predicted Correct (%)	Key	Student Choices (%) A	B	C	D	E	Omits
Knowledge	17	47	E	7	11	5	32	41	3
	45	39	D	11	9	8	53	17	3
	105	48	E	4	7	18	8	60	3
	137	46	D	16	9	4	65	3	3
Application	14	41	B	11	40	19	10	12	7
	15	60	A	59	18	11	4	2	5
	44	50	A	45	7	5	34	6	4
	46	45	A	24	14	18	17	23	3
	74	46	A	36	25	8	5	23	4
	75	49	A	41	32	10	2	11	4
	106	35	A	15	9	10	54	8	4
	107	43	A	24	15	31	13	14	3
	134	40	D	18	33	16	22	9	3
	136	41	A	57	10	14	8	8	3
Higher Order Skills	16	44	D	16	13	20	26	20	4
	47	34	E	41	17	20	9	9	4
	76	22	B	9	50	13	10	12	5
	77	32	D	10	12	13	44	16	4
	104	50	B	24	39	6	7	19	4
	108	37	E	6	15	9	10	54	6
	135	30	B	11	15	18	14	38	3

Display 49 (continued)
Detailed Item Analysis for Student Achievement Questions
Provincial Results - Physics

Atomic Structure & Nuclear Physics / *Process Level*	*Item No.*	*Teacher Predicted Correct (%)*	*Key*	*Student Choices (%)*					
				A	*B*	*C*	*D*	*E*	*Omits*
Knowledge	19	28	C	7	14	43	10	19	7
	50	38	C	27	10	34	18	4	7
	79	29	D	14	16	21	29	14	6
	109	35	D	11	5	5	50	23	5
	138	26	E	24	22	13	22	15	4
	140	28	B	14	17	12	32	20	6
	18	31	B	26	32	19	9	5	9
Application	20	18	B	7	67	8	5	3	9
	48	47	B	14	55	12	10	7	3
	49	35	A	20	13	23	26	11	6
	78	28	D	34	14	13	28	6	5
	80	31	D	7	11	14	44	16	7
	139	33	D	13	29	19	26	7	6
Higher Order Skills	110	33	D	22	13	9	42	6	7

to describe the scientific method and design an experiment.

For the purposes of analysis each dimension for each extended-response question was subdivided into a number of different categories.

For the purposes of this analysis the term "**DIMENSION**" is intended to indicate an aspect of the Senior Division, Advance Level Physics Program. Typical examples include laboratory skills, safety awareness, knowledge, and applications of laws and principles. Several of these dimensions were examined in different contexts using different questions.

Each dimension was then subdivided into a numbered "**CATEGORY**" which indicates the level of student achievement in each dimension. It is important to realize that the assignment of a category to a student response is not necessarily an indicator of a "mark" in the traditional sense but an indication of student achievement in a certain dimension. Examination of the categories for any of the dimensions of the questions show that, for example, while category 4 represents a higher level of achievement than Category 2, it is not necessarily in a numerical ratio of 4:2. In other words Category 4 of 5 categories does **not** imply a "mark" of 4 out of 5.

Display 50(a-e) contains the data on the student achievement for the five extended-response questions. These questions have been scored by the Ministry for provincial review schools only.

Student achievement was best in two areas - sketching a force diagram and finding the net force (Question 4). Students also did well in measuring the angle of incidence (Question 3) and describing the scientific method (Question 5). The highest percentage of incorrect responses occurred for the calculation of the index of refraction (Question 3) and solving for acceleration (Question 4).

Specific comments from the analysis team on the student responses to each question can be found in the appendices.

10.3 The Interpretation Panel

Following collection and scoring of the results an interpretation panel consisting of members of various educational and public constituencies met to consider the levels of student achievement seen in this provincial review. The panel examined student achievement for each question against a background of their professional judgement andd their understanding of the student population, curriculum emphases, current classroom practices, the curriculum and public expectations. It provided interpretive comments on student performance in the review. The panelists also provided recommendations regarding current practices in Senior Division Physics that may improve student achievement.

Panelists were provided with the student assessment booklets in advance of the meeting and were asked to identify individually "acceptable" and "desirable" levels of performance for each question. In effect, this was Phase I of a six-part process. In Phase II the student achievement data was then provided and panelists individually rated student performance according to the following five point scale:

5 = Superior
4 = Strong
3 = Satisfactory
2 = Marginal
1 = Weak

In Phase III groups of 3 or 4 panelists were formed. Each group was asked to discuss individual ratings for items in two content domains and arrive at a consensus rating for each item. They were also asked to watch for strengths and weaknesses and patterns. Each group then was asked to reach consensus on a rating for each content domain.

In Phase IV the groups were brought together and a single rating was established for each item and domain with input from the entire group.

In Phase V three small groups reorganized consensus ratings for each item according to the process levels of Knowledge, Application and

Display 50a
Percentage of Student Responses Falling Within Various Response Categories for the Components of the Extended Response Achievement Questions
Provincial Results - Physics

Dimension A: Interpretation of Data	*(%)*
No response	5
The numerical portion of the unit is incorrect	39
The numerical portion of the answer is correct but the unit is missing or incorrect	4
The numerical portion of the answer is correct and the unit of seconds is stated	27
The correct answer including the unit is given in a word statement	26

Dimension B: Making Accurate Measurements	*(%)*
No response	9
More than two of the possible errors are shown	21
The position values show a failure to accumulate interval distances from the start	3
Table has two of the possible errors	18
Table has one of the possible errors	37
Table is complete and correct	13
Possible errors:	
an error in position	
an error in time	
failure to record 0, 0 and/or the 0 digit in the ...	

Dimension C: Interpretation of Data About Motion	*(%)*
No response	14
An incorrect response is given	12
One term is used correctly	19
Two of the terms are correctly used	26
All three terms are used correctly but the acceleration is not identified as constant	21
All three terms are used correctly and the acceleration is identified as constant	9

Display 50b
Student Achievement on Extended Response Question 2
Provincial Results - Physics

Dimension A: Draw and Label Diagrams	*(%)*
No response	7
Some attempt has been made but no correct ray is shown	27
One correct ray was selected but the effect of the lens on either is shown incorrectly	17
Two suitable rays were selected but the effect of the lens on either is shown incorrectly	7
Suitable rays were selected and the effect of the lens on the rays is incorrectly shown	9
The image has been correctly located using proper rays but two of the above have been omitted	17
The diagram is correct, but one of the following is omitted - no arrowheads in solid rays appropriate lines shown as dotted an arrowhead on the image	12
The image is shown as dotted with the correct postion and attitude. Suitable rays were used and projected back as dotted with arrowheads on both solid rays	5

Dimension B: Interpretation of Data on a Diagram	*(%)*
No response	9
No correct characteristic is stated	15
One of the characteristics is stated	12
Any two are stated	24
Any three of the characteristics are stated	40

Display 50c
Student Achievement on Extended Response Question 3
Provincial Results - Physics

Dimension A: Making Accurate Measurements	*(%)*
No response	10
The angle stated is outside the tolerance allowed	21
The correct angle is stated but no symbol for degrees is shown	0
The correct angle is stated along with the symbol for degrees	42
The correct angle is stated along with the unit of degrees in a word statement	27

Dimension B: Solving a Numerical Problem on Refraction	*(%)*
No response	34
An attempt has been made but no correct relationship is stated	28
Only the correct relationship has been stated	2
The solution has three of the errors	3
The solution has two of the errors	7
The solution has one of the errors listed below - no relationship stated no statement of substitution no concluding statement an error in the calculation no units with the answer	18
The solution is complete and correct	8

Dimension C: Draw and Label Diagrams	*(%)*
No response	20
Only the refracted angle is drawn but the value is outside the tolerance accepted	27
Three of the components are missing	7
Two of the components are missing	11
One of the following components is missing or the angle of refraction is greater than 40 degrees	16
The refracted ray is drawn so that it is between 24 and 26 degrees or the answer found in part b provided it is less than 40 degrees - the angle of refraction is labelled - the angle of incidence is labelled	19

Display 50d
Student Achievement on Extended Response Question 4
Provincial Results - Physics

Dimension A: Draw and Label a Diagram	*(%)*
No response	3
Neither vector is correct and/or properly labelled	4
Object is shown with one vector correct and properly labelled	2
Object is shown with two vectors in opposite directions but incomplete or incorrect labels	23
Object is shown with two vectors in opposite directions properly labelled	69

Dimension B: Solving a Numerical Problem on Forces	*(%)*
No response	6
An attempt has been made but the value of the force is incorrect	19
The correct net force is stated but the unit or direction is incorrect or omitted	0
The correct value for net force is given but either the unit or direction is incorrect or omitted	10
A mathematical statement or a free body diagram with the net force show is used indicating the correct value, unit and direction	37
A word statement which states the correct net force, including unit and direction	27

Dimension C: Solving a Numerical Problem on Acceleration	*(%)*
No response	22
An attempt is made but the relationship stated is incorrect	29
The correct relationship is stated	1
The solution includes three of the errors	12
The solution includes two of the errors	22
The solution includes one of the errors listed below no statement of the relationship no substitution statement an error in the calculation or substitution no final statement error in or omission of the unit error in or omission of the direction	12
Complete, correct solution including a final statement	2

continued -

Display 50d (Continued)
Student Achievement on Extended Response Question 4
Provincial Results - Physics

Dimension D: Solving a Numerical Problem on Velocity	*(%)*
No response	26
An attempt is made but the relationship stated is incorrect	32
The correct relationship is stated	2
The solution includes three of the errors	20
The solution includes two of the errors	13
The solution includes one of the following errors - no statement of the relationship no substitution statement an error in the substitution or calculation no final statement error in or omission of the unit error in or omission of the direction	7
Complete, correct solution including a final statement	1

Display 50e
Student Achievement on Extended Response Question 5
Provincial Results - Physics

Dimension A: Describe the Scientific Method	*(%)*
No response	5
None of the steps are listed but some attempt has been made	3
One of the steps is listed	5
Two of the steps are listed in order	9
Three of the steps are listed in order	19
Four of the steps are listed in order	49
All five key steps above are listed in order	10

Dimension B: Design an Experiment	*(%)*
No response	21
An attempt is made which refers to the problem	14
One step is described	18
Two steps are described	16
Three steps are described	14
Four steps are described	11
Five steps are described	5
Six steps are described	1
All seven steps are reasonably described in relation to the problem provided	0

Higher Order Thinking and established a rating for that process level. The groups reconvened and a single consensus rating was established for each process level. The ratings by content domain and process levels are shown in Display 51.

The panel felt that the results were satisfactory in four of the six content domains. They were considered marginal in Light and Atomic Structure and Nuclear Physics. The performance in each of the process levels was rated as satisfactory.

Display 52 provides the ratings of provincial student achievement on each individual question.

In Phase VI panelists examined the data for the extended-response questions. Individually they rated the results of each dimension for each question. The ratings were presented and a consensus rating was obtained for each dimension and then for each question. The questions on refraction and designing an experiment according to the scientific method (Questions 3 and 5) received marginal ratings while student performance on the others was considered satisfactory.

During the analysis of the results the panel expressed concern about two of the selected-response questions. For question 68 it was felt that the interference of sound effect expected in the correct answer would not always be detectable for all frequencies. Without the interference other answers become possible. It was also felt that question 130 did not give enough information

Display 51
Interpretation Panel Ratings of Student Achievement by Content Domain and Process Level
Provincial Results - Physics

Content Domain	*Mean % Correct*	*Rating*
Mechanics	52	2.8
Waves and Sound	49	2.9
Light	41	2.6
Current Electricity	49	3.1
Electromagnetism	39	2.7
Atomic Structure and Nuclear Physics	36	2.4
Process Level	*Mean % Correct*	*Rating*
Knowledge	49	2.9
Application	45	2.7
Higher Order Skills	37	2.7

Display 52
Interpretation Panel Ratings of Student Achievement
by Individual Questions Together with Summary Question Data
Provincial Results - Physics

Mechanics	*P Value*	*OTL*	*TPC*	*IPR*
Knowledge				
3. Work is always done when...	44	95	64	2
61. Which one of the following is...	58	98	74	3
91. An object moving at a constant...	54	98	70	3
122. Action and reaction forces always...	32	95	54	2
Application				
1. A cart, initially at rest, is pulled...	49	96	63	3
2. Suppose that the only forces acting...	45	97	67	2
32. A lead mass is suspended by a string...	26	95	55	1
33. In the accompanying diagram...	42	91	53	2
62. A baseball of mass 0.200 kg has a...	34	94	68	2
64. A car starts from Hither, goes to...	92	100	71	5
65. An elevator moves from the basement...	64	98	63	3
92. Which segent of the graph shows the...	50	98	63	3
93. What minimum work is required to...	53	95	65	3
94. A 50 W light bulb operating for 20 s...	73	96	60	4
123. An object of mass 5.0 kg at the...	69	97	74	3
124. A man pushed a stalled car with a...	48	95	59	3
Higher Order Skills				
4. A cross section of a frictionless...	17	87	42	1
31. Which graph represents the motion...	63	97	66	4
63. The diagrams below show different tests...	59	86	46	3
121. Consider... The average speed is...	63	98	64	4

Display 52
Interpretation Panel Ratings of Student Achievement
by Individual Questions Together with Summary Question Data
Provincial Results - Physics

Waves and Sound	*P Value*	*OTL*	*TPC*	*IPR*
Knowledge				
5. The following... Which one of the labelled...	76	84	62	5
34. Two waves X and Y travel in opposite...	57	88	54	3
67. Consider the following wave diagram...	91	93	74	5
Application				
6. The diagrams below represent four different...	64	77	53	4
36. The wave disturbance shown below is...	19	88	48	1
37. If a wave train has a period of 2.00 s...	72	92	55	5
66. This diagram shows two wave pulses...	59	83	52	3
95. A pendulum makes 40 vibrations...	31	97	69	2
96. Vibrations are created at one end...	22	91	40	1
125. Waves generated at A are reflected...	57	87	55	3
126. A siren is located due west of your...	32	89	46	2
127. A sound wave has a wavelength of 3.0 m...	42	90	53	2
Higher Order Skills				
35. Points 1, 2, 3, 4, and 5 are marked...	45	86	46	3
68. A stationary loud speaker sends...	14	74	36	1

Display 52
Interpretation Panel Ratings of Student Achievement
by Individual Questions Together with Summary Question Data
Provincial Results - Physics

Light	*P Value*	*OTL*	*TPC*	*IPR*
Knowledge				
7. When a light ray travels at an oblique...	58	88	67	3
38. The image in a pinhole camera is ...	39	72	46	3
69. The phenomena of light bending as it...	79	89	73	4
70. Where must an object be placed ...	46	85	53	3
98. The image of a candle produced by a...	21	77	48	1
99. The amount of light entering the eye...	47	68	49	2
129. Where must a point light source be...	48	86	51	3
Application				
8. An object is placed near a convex...	48	86	55	3
71. Which instrument makes use of one double...	31	71	36	2
128. Which diagram below best illustrates...	32	88	57	2
Higher Order Skills				
9. The lens in the human eye is surrounded...	29	39	23	3
39. Which of the diagrams below correctly...	35	80	45	2
97. An object is located 30 cm from a convex...	27	82	38	2
130. Which is the correct diagnosis for...	36	63	34	3

Display 52
Interpretation Panel Ratings of Student Achievement
by Individual Questions Together with Summary Question Data
Provincial Results - Physics

Current Electricity	*P Value*	*OTL*	*TPC*	*IPR*
Knowledge				
12. Twelve 1.5 V dry cells connected in...	55	78	56	3
40. One volt is equivalent to...	40	92	57	3
73. What is the effect when a second...	58	89	59	3
101. Current is a measure of...	58	93	68	3
Application				
10. Resistances of 2.0 j and 6.0 j...	63	89	64	4
11. A current of 0.50 A flows through...	66	90	69	4
41. An electric motor connected to a 100 V...	40	84	49	3
43. In the following circuits an ammeter...	51	87	59	3
72. A current of 0.80 A flows for 1.0 min. ...	46	92	58	3
100. A 6.00 V battery delivers 2.00 A ...	33	90	53	2
102. A 12 j resistor is connected in...	41	88	63	3
131. An electric heater operating on a...	75	89	64	5
132. When a 12.0 V battery delivers 15.0 A...	62	87	62	3
Higher Order Skills				
13. This question involves two statements...	41	73	41	3
42. A total resistance of 3.0 j is to be...	57	87	45	4
103. Two identical resistors are connected...	27	88	45	2
133. The diagram below shows a circuit...	28	87	48	2

Display 52
Interpretation Panel Ratings of Student Achievement
by Individual Questions Together with Summary Question Data
Provincial Results - Physics

Electromagnetism	*P Value*	*OTL*	*TPC*	*IPR*
Knowledge				
17. Consider the following factors for a...	41	62	47	3
45. The reason that some materials are...	53	61	39	4
105. Soft iron is used in the cores of...	60	70	48	4
137. A step-down transformer is used to...	65	53	46	4
Application				
14. A simple DC motor is connected so...	40	59	41	3
15. A single straight conductor carries...	59	74	60	3
44. Consider the following changes...	45	71	50	3
46. The diagram illustrates a straight...	24	63	45	1
74. If other factors remain constant...	36	68	46	3
75. A permanent magnet is held...	41	66	49	3
106. A transformer has 500 turns in the...	15	50	35	1
107. The diagram shows a wire in which...	24	71	43	1
134. A segment of a copper conductor is...	22	74	40	2
136. A generator supplies 200 V to the...	57	54	41	3
Higher Order Skills				
16. As shown by the arrow in the diagram...	26	62	44	3
47. This question involves two statements...	9	50	34	1
76. If M represents the change in magnetic...	50	46	22	4
77. In the diagram below, the primary coil...	44	56	32	3
104. The diagram shows the polarity of...	39	73	50	2
108. The diagram represents a primary coil...	54	57	37	4
135. Consider a copper block moving...	15	58	30	2

Display 52
Interpretation Panel Ratings of Student Achievement
by Individual Questions Together with Summary Question Data
Provincial Results - Physics

Atomic Structure and Nuclear Physics	*P Value*	*OTL*	*TPC*	*IPR*
Knowledge				
19. The main purpose of heavy water in...	43	35	28	3
50. X rays have...	34	39	38	2
79. The function of the control rods in...	29	33	29	2
109. Which of the following has the most...	50	41	35	3
138. Consider the following quantities...	15	35	26	2
140. The energy from nuclear fission...	17	38	28	1
Application				
18. Which nucleus represents the missing...	32	39	31	2
20. A gamma ray source and a Geiger counter...	67	14	18	4
48. The element manganese has an atomic...	55	55	47	3
49. If 225Ra gives off a negative beta...	20	38	35	1
78. A beta particle is deflected more...	28	36	28	2
80. The nuclear reaction...	44	35	31	3
139. If 226Ra gives off an alpha particle...	26	39	33	2
Higher Order Skills				
110. This question involves two statements...	42	44	33	3

Display 53
Percentage of Students Providing Various Response Options for the Attitude Scales Items
Provincial Results - Physics

Attitude Scale *Science and Experiments*	*Student Responses*				
	Strongly Disagree	*Dis-Agree*	*Un-Decided*	*Agree*	*Strongly Agree*
I prefer to read why things happen rather than to do an experiment to find out.	24	44	15	14	4
I would rather watch the teacher do experiments than to do them myself.	28	44	13	10	4
It is better to be told scientific facts than to try to discover them from experience.	21	44	19	12	3
Doing experiments is too slow a way to learn science.	25	49	15	10	2
Doing experiments did not help me learn science.	32	53	7	6	2
I would like to spend more time doing experiments.	3	12	23	45	17
I find that doing experiments helps me to understand science.	3	7	11	55	24
I would rather do experiments myself than watch other students do them.	3	13	14	45	24
I would rather work with someone else than do experiments by myself.	4	7	12	50	27
I like to try out new ideas by doing science experiments.	2	11	24	49	14
I am interested in the unexpected results that sometimes occur in science experiments.	3	9	17	55	16
I enjoy demonstrations or experiments which give unexpected results.	3	8	16	54	18

Display 53 (continued)
Percentage of Students Providing Various Response Options for the Attitude Scales Items
Provincial Results - Physics

Attitude Scale *Careers in Science*	*Student Responses*				
	Strongly Disagree	*Dis-Agree*	*Un-Decided*	*Agree*	*Strongly Agree*
Working in a science laboratory would be an interesting way to earn a living.	5	14	20	49	12
In the future most jobs will require a knowledge of science.	2	10	14	54	19
People who understand science are better off in our society.	5	19	18	43	14
It is important to know science in order to get a good job.	9	40	17	28	6
Science is a very good field for creative people to be in.	5	14	21	44	16
In my future career I would like to use the science I learned in school.	6	12	30	34	18
People who work with modern inventions such as computers have more interesting jobs.	14	41	21	16	7

Display 53 (continued)
Percentage of Students Providing Various Response Options for the Attitude Scales Items
Provincial Results - Physics

Attitude Scale Gender and Science	*Student Responses*				
	Strongly Disagree	*Dis-Agree*	*Un-Decided*	*Agree*	*Strongly Agree*
Men make better scientists and engineers than women.	51	25	9	6	9
Boys have more natural ability in science than girls.	43	28	12	11	6
Boys need to know more science than girls.	45	34	11	5	4
A woman needs a career just as much as a man does.	6	4	8	29	51

Display 53 (continued)
Percentage of Students Providing Various Response Options for the Attitude Scales Items
Provincial Results - Physics

Attitude Scale *Science and Society*	*Student Responses*				
	Strongly Disagree	*Dis-Agree*	*Un-Decided*	*Agree*	*Strongly Agree*
Science is useful for solving the problems of everyday life.	2	9	10	58	20
Science has ruined the environment.	13	37	31	15	3
Science is very important for a country's development.	1	2	7	50	40
Money spent on science is well worth spending.	1	4	22	52	21
Much of the anxiety in modern society is due to science.	5	31	34	24	6
Public money spent on science in the last few years has been used wisely.	3	17	52	24	3
Scientific inventions improve our standard of living.	1	3	12	55	29
The government should spend more money on scientific research.	3	11	38	35	13
Scientific inventions have made the world too complex.	11	45	20	20	3
Scientific inventions have increased tensions between people.	6	26	25	34	9
Science will help to make the world a better place in the future.	3	7	30	41	18
Scientific discoveries do more harm than good.	15	47	31	5	1
Science and technology are the causes of many of the world's problems.	9	31	25	27	7
I want to learn more about the world we live in.	1	2	8	44	43

Display 53 (continued)
Percentage of Students Providing Various Response Options for the Attitude Scales Items
Provincial Results - Physics

Attitude Scale *Science as a Process*	*Student Responses*				
	Strongly Disagree	*Dis-Agree*	*Un-Decided*	*Agree*	*Strongly Agree*
Science will change rapidly in the near future.	2	7	13	52	26
Science is a good field for creative people.	3	15	13	54	16
There is little place for originality in solving science problems.	11	33	23	27	7
New discoveries in science are constantly being made.	1	3	7	59	29
Science helps one to think according to strict rules.	4	27	25	37	8
Estimating is an important science skill.	3	17	19	50	11
There are many different ways to solve most science problems.	2	21	15	51	10
Learning science involves mostly memorizing.	9	42	10	30	9
In science, problems can often be used to solve a science problem.	22	46	13	17	3
Trial and error can often be used to solve a science problem.	3	13	15	58	11
There is always a rule to follow in solving a science problem.	3	21	20	45	11

Display 53 (continued)
Percentage of Students Providing Various Response Options for the Attitude Scales Items
Provincial Results - Physics

Attitude Scale *Physics in Schools*	*Student Responses*				
	Strongly Disagree	*Dis-Agree*	*Un-Decided*	*Agree*	*Strongly Agree*
If properly taught, almost all students could learn Physics.	3	16	9	54	18
Physics is an enjoyable school subject.	4	15	23	49	8
The Physics taught at school is interesting.	3	14	20	53	9
Physics is a difficult subject.	3	25	11	46	15
Physics is difficult when it involves calculations.	10	43	15	26	5
Physics is difficult when it involves handling apparatus.	13	62	14	10	1
There are too many facts to learn in Physics.	4	32	28	27	9
Physics is relevant to life.	3	9	15	48	24

to make a clear choice possible from the distractors provided.

The members of the panel provided some thoughts on the physics review. It was suggested that in general the questions seemed difficult with perhaps too many application questions. Some booklets were more difficult than others. However the view was also expressed that the questions provide an indication of what should be expected of the students and where the emphases should be placed during instruction. Although the review process is a good one it is important to recognize that the flexible timing permitted for the administration of the student achievement component will reflect a difference in course coverage, particularly between semestered and non-semestered schools.

A board may wish to examine the ratings of the provincial results by this interpretation panel in relation to their own results. The document *A Guide for Interpreting Board Results* provides details concerning this process.

10.4 Student Attitudes Towards Science

Each student answered questions related to attitudes to the physics course. Since each of the five booklets contained different sets of questions, attitude data were collected for six different sets of questions (one booklet contained two sets of questions). One fifth of the students in each school answered each collection of questions.

Six sets of questions (or scales) were responded to by students:

- Science and Experiments (12 questions)
- Careers in Science (7 questions)
- Gender and Science (4 questions)
- Science and Society (14 questions)
- Science as a Process (11 questions)
- Physics in Schools (8 questions)

Display 53 provides details of the responses given to these questions.

Laboratory Work Most students feel that doing experiments should be part of a science course. Experiments help them to understand science. They enjoy experiments which give unexpected results. Students want to be actively involved but prefer to work with someone rather than alone.

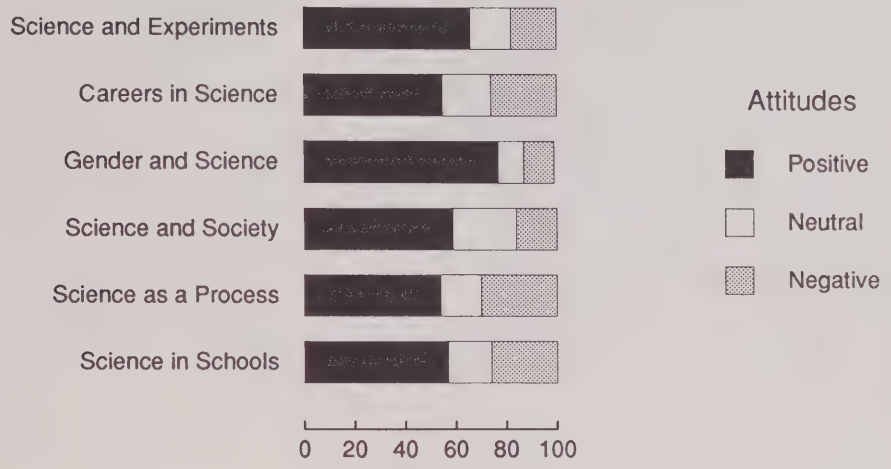
Careers in Science Student responses about careers in science were generally positive but somewhat mixed. THe majority believe that people who understand science are better off in our society. Most feel that knowledge of science will be required in the future in most jobs but it is not important in order to get a good job. They also believe that scientific research would be interesting and that science is a good field for creative people but only half would like to use the science they learn in school in their own careers. They do not believe that people who work with modern inventions have more interesting jobs.

Science and Society Science is important to a country's development and worth the money spent on it. Science is useful for solving the problems of everyday life and scientific inventions improve our standard of living. These views are shared by a large majority of students. They are also curious. Almost nine of ten indicated a desire to learn more about their world. A majority also believe that science will help make the world a better place.

Gender and Science Males do not have any advantage over females in areas involving science. About three students out of four do not believe males have more natural ability in science or need to know more science. They feel that women need careers just as much as men. These views are encouraging in the light of the emphasis on sex equity in the new guideline.

Science as a Process The perceptions of science as a process vary. Science is a creative, somewhat flexible, rapidly changing process according to most students. A majority believe that there are many different ways to solve most science problems, including trial and error. However, about half of the students feel that there is always a rule to follow in solving a science problem and that science helps one think according to strict

Display 54
Percentage of Students Indicating Positive, Neutral, and Negative Attitudes Towards Science on the Various Attitude Scales
Provincial Results - Physics



rules. As well over one-third said that learning science involves mostly memorization.

Physics in Schools According to three students in four, physics is relevant to life and if properly taught, it could be learned by almost all students. Most concede that it is a difficult subject but find it interesting and enjoyable.

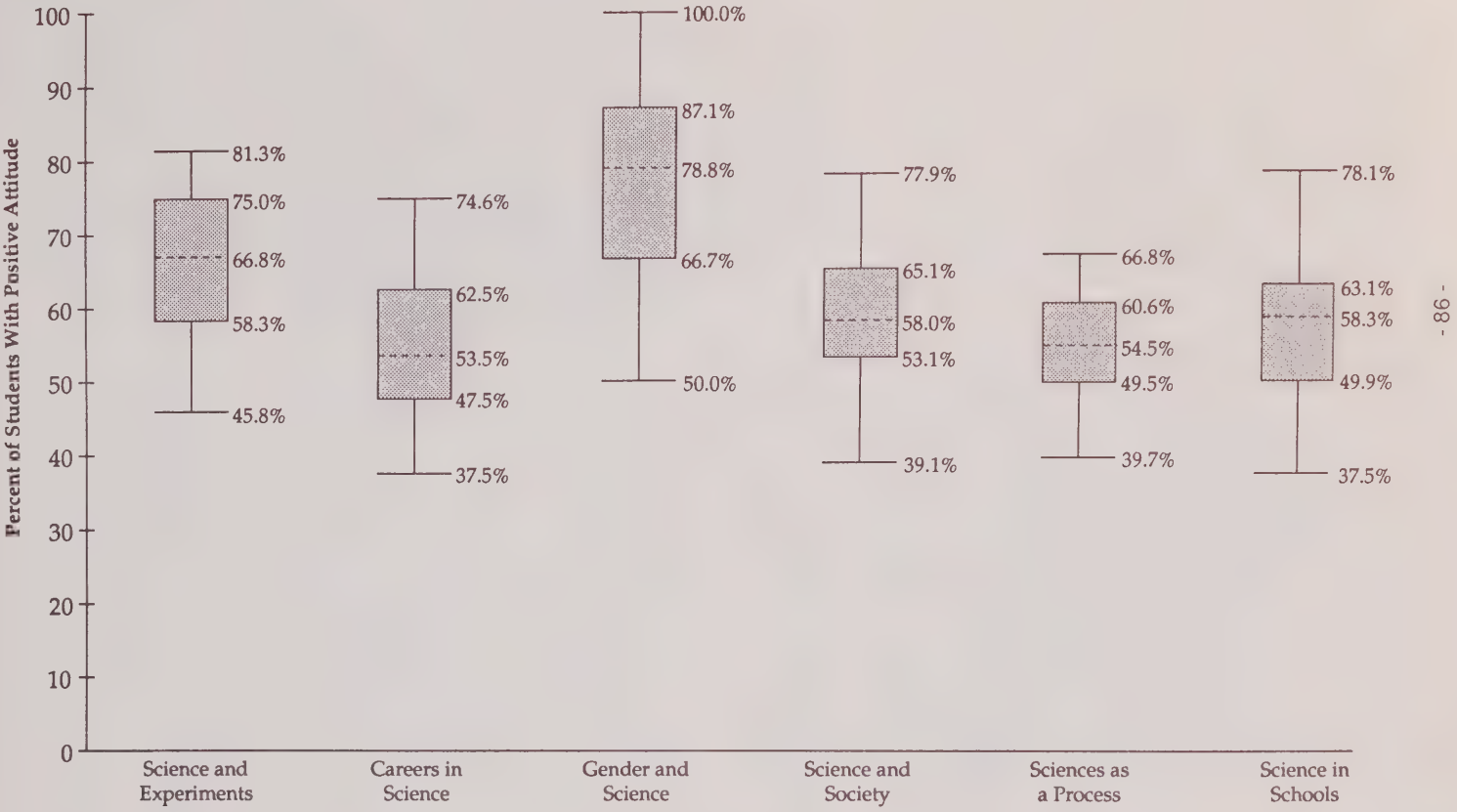
Display 54 provides a summary of the percentage of students providing positive, neutral, or negative attitudes towards science for each scale. The categorizations were made by identifying the range of possible responses for each scale and identifying the percentage of students falling in the highest, middle, and lowest third of the range.

Student attitudes were generally positive on all attitude scales but strongest for gender and science as well as for science and experiments. The greatest number of neutral responses occurred for science and society. The greatest percentage of negative responses were found for the questions on science as a process which seems to suggest that students are receiving different messages throughout the province about process.

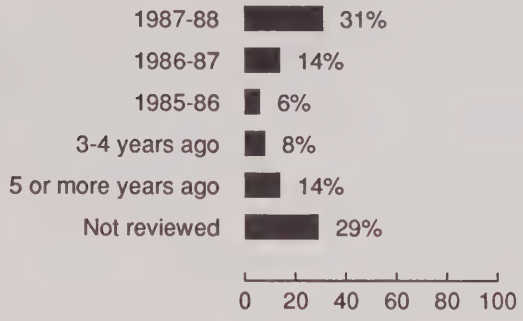
Display 55 provides information concerning the range of student attitudes.

Display 55

Variation Among Schools in Average Student Attitudes Towards Science



Display 56
The Review Process: Percentage of Schools
Reporting the Occurrence of Their Most Recent Course Review
Provincial Results - Physics



11. Curriculum Management

A separate questionnaire inquired into approaches to curriculum management at the school level. Curriculum management was seen as consisting of three components: review, development, and implementation. The person responsible for managing curriculum, usually the science department head, was asked to provide details concerning this process. The data are presented in a series of 10 displays focussing on the components of Review, Development and Implementation.

11.1 Reviews At The Local Level

Department heads reported the occurrence of their most recent review and this data is presented in Display 56. If a review did not occur, the respondent was asked to omit the remaining questions. If a review did take place, the process by which the review was conducted was indicated.

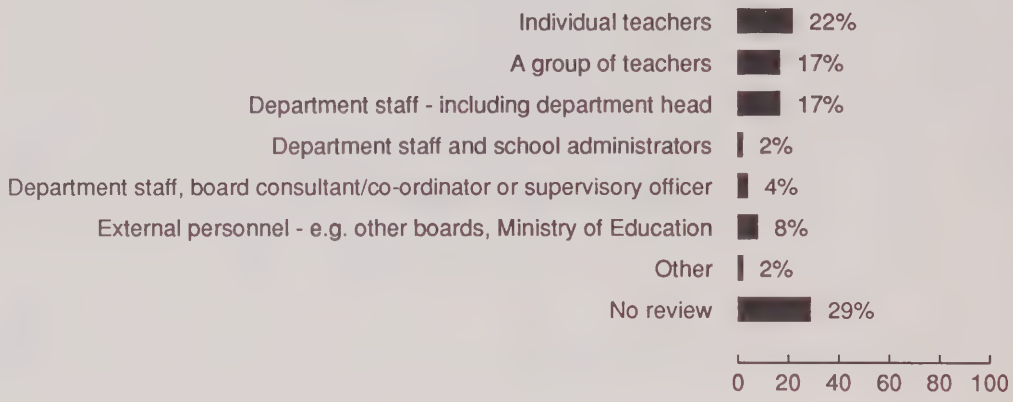
Almost one-third reported that the course had been reviewed during the current school year. Just over one-quarter had reviews done within the last 4 years. However, three in ten said that no review has occurred at all.

Display 57 shows the percentage of schools reporting the procedure by which the most recent course review was conducted.

When reviews are conducted, about half are conducted by a group of teachers or department staff including the head. Individual teachers are responsible for the review in about one-third of the cases.

There are a number of reasons which can prompt a course review. Choosing from six options, department heads indicated the single most important reason for instituting a course review. Display 58 shows the percentage of department heads

Display 57
The Review Process: Percentage of Schools Reporting Procedure by Which Most Recent Course Review Was Conducted
Provincial Results - Physics


Individual teachers 22%
A group of teachers 17%
Department staff - including department head 17%
Department staff and school administrators 2%
Department staff, board consultant/co-ordinator or supervisory officer 4%
External personnel - e.g. other boards, Ministry of Education 8%
Other 2%
No review 29%
0 20 40 60 80 100

reporting each of these reasons for the most recent review.

Most course reviews were conducted in response to a Ministry of Education initiative such as the release of a guideline. Currently the ministry is encouraging boards to put in place a curriculum management process which includes a review component. Less than one-quarter of the heads report the existence of such a procedure at this time.

Other aspects of the review process include the influence of various sources on the decision to conduct a review and the resources used to conduct the review. Department heads reported on the degree of influence exerted by various sources, including students, teachers, and board officials, on the initiation of the review. Display 59 presents the percentage of heads reporting these data while Display 60 shows the level of resources used in conducting the course review.

The initiation of a course review was clearly influenced most by teachers and department heads. Ministry of Education guidelines were used most by teachers in carrying out reviews. In addition the current course of study is used to some degree by almost all teachers. Textbooks have some influence according to most respondents. A school

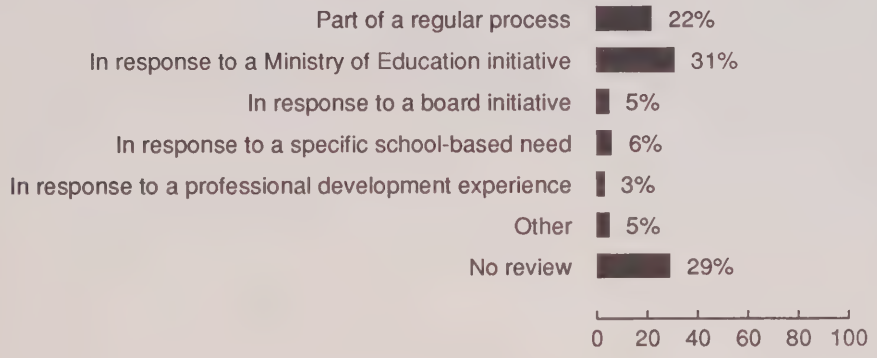
board's program documents are used by just over half of the teachers.

11.2 The Course Development Process

Inquiries were also made concerning the course development process. Display 61 summarizes the process by which development was undertaken. It is interesting to note that in almost one-third of the cases where some course review has been carried out, no development or revision of course components has occurred as a result. When development or revision of a course components did occur it was done by individual teachers in the vast majority of cases.

Display 62 shows the level of involvement of various individuals in recent course development. Teachers had the greatest involvement in developing or revising course components with department heads involved to a lesser extent. It is of

Display 58
The Review Process: Percentage of Schools Reporting the Single Most Important Reason for Most Recent Course Review
Provincial Results - Physics



some significance to note that students were idntified as the next largest group involved.

Display 63 provides the percentage of schools using varying levels of resources in course development. As with the review of courses, Ministry of Education guidelines were used the most in developing or revising course components. The existing course of study and textbooks were used to some extent by most teachers. Again school board program documents were only used by half the teachers.

Display 59
The Review Process: Percentage of Schools Reporting the Level of Influence Exerted by Various Sources On the Initiation of the Course Review
Provincial Results - Physics

Variety of Individuals	*Degree of Influence*		
	None	*Some*	*Much*
Students	69	25	6
Teachers	25	23	51
Department Heads	23	29	48
Principal/Vice Principal	74	17	9
Consultant/Co-ordinator	74	19	7
Board Supervisory Official	76	14	11
Ministry of Education Official	69	13	18
Trustees	96	5	0
Community	93	7	0
Other	96	1	4

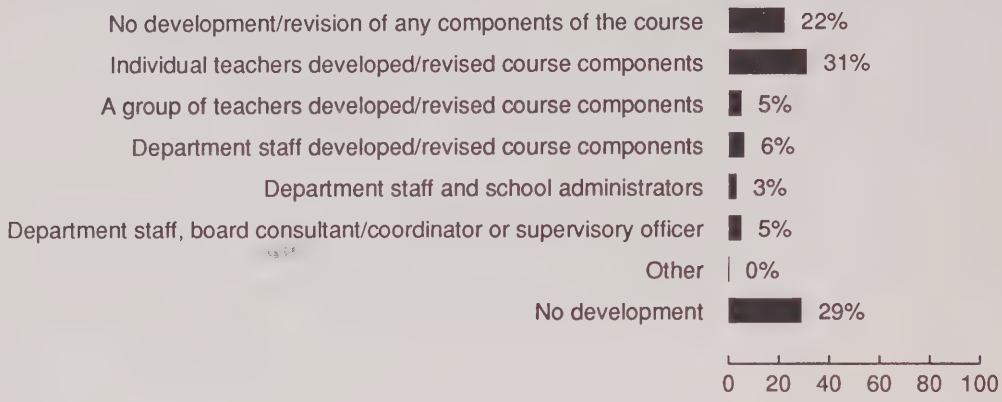
11.3 The Implementation Process

Concerning the implementation process, a variety of factors have been identified as influencing the implementation of course changes. Department heads indicated whether these factors had been positive, negative or neutral influences upon the implementation of changes. Display 64 shows that teacher to teacher interaction including coaching has the greatest influence on getting program changes implemented. The availability and use of external resources, support from all levels and the clarity of the change also exert very positive influences. The number of courses to change, that

Display 60
The Review Process: Percentage of Schools Reporting Varying Levels of Use of Resources in the Review
Provincial Results - Physics

Types of Resources	*Extent of Usage*		
	None	*Some*	*Much*
Ministry of Education Guidelines	6	27	67
The School Board's Program Documents	47	31	22
Other Boards' Program Documents	78	20	2
Your School's Existing Course of Study	5	45	51
Other Schools' Courses of Study	65	29	6
Materials from Professional Organizations	45	46	9
Educational Research	58	36	6
Textbooks	23	51	26
Other	96	1	4

Display 61
The Development Process: Percentage of Schools Reporting Process by Which Most Recent Development Was Undertaken
Provincial Results - Physics



is the extent of the change, has the greatest negative influence. The quality and availability of materials are critical influences because they can have either positive or negative effects.

Display 65 summarizes the effects of the review, development a implementation process upon various course components. These components include the teaching rationale, sequence and timing of objectives, modifications for exceptional students, and Canadian science and scientists. The traditional components of a course were the ones most commonly reviewed - sequence and timing of objectives, teaching strategies, laboratory activities and student assessment strategies and resources. Components were developed for these in almost all of the cases where review took place. The most extensive implementation of these changes took place in the sequence and timing of objectives andresources. Moderate implementation has occurred in laboratory activities and teaching strategies. Some significant review, development and implementation is taking place in safety, mode of delivery and career awareness which are important components in the new guideline.

Display 62
The Development Process: Percentage of Schools Reporting the Level of Involvement of Various Sources with Recent Course Development
Provincial Results - Physics

Individual/Groups	*Extent of Involvement*		
	None	*Some*	*Much*
Students	71	27	2
Teachers	3	18	79
Department Heads	15	34	51
Principal/Vice Principal	88	11	1
Consultant/Co-ordinator	73	19	8
Board Supervisory Official	87	11	3
Ministry of Education Official	84	13	3
Trustee	99	1	0
Community	96	4	0
Other	97	1	2

Department heads were asked to judge the current and desired influence of principals and department heads on the curriculum management process. The data is found as Display 66. Department heads report they have a definite influence on the curriculum management process and they would like to see that influence increase. They report also that principals have relatively little influence except in determining the need for a course review. Greater principal influence would also be desirable.

Display 63
The Development Process: Percentage of Schools Reporting Varying Levels of Use of Resources in the Review
Provincial Results - Physics

Types of Resources	*Extent of Usage*		
	None	*Some*	*Much*
Ministry of Education Guidelines	4	18	78
The School Board's Program Documents	46	33	21
Other Boards' Program Documents	73	25	2
The School's Existing Course of Study	5	44	51
Other Schools' Courses of Study	57	38	5
Materials from Professional Organizations	51	42	7
Educational Research	61	36	3
Textbooks	18	54	28
Other	96	3	1

Display 64
The Implementation Process: Percentage of Schools Rating Various Factors as Either Positive, Negative, or Neutral Influences in the Implementation of Course Changes
Provincial Results - Physics

Types of Factors	*Type of Influence*		
	Positive	*Negative*	*Neutral*
Number of Courses to Change	12	52	37
Board Support	44	4	52
Community Support	11	0	89
Timeline for Change	39	26	35
Clarity of the Change	44	14	41
Quality and Availability of Materials	45	24	31
Principal/Vice Principal Involved/Support	36	2	63
Consultant/Co-ordinator Involved/Support	40	0	60
Relevance and Amount of In-service	35	8	58
Teacher to Teacher Interaction/Coaching	76	2	22
Availability/Use of External Resources	48	3	49

Display 65
Summary of Review, Development, and Implementation Practices:
Percentage of Schools Reporting Various Course Components
Influenced by the Curriculum Management Process
Provincial Results - Physics

Components	*Component Reviewed*		*Component Developed*		*Changes Implemented*			
	Yes	*No*	*Yes*	*No*	*None*	*Little*	*Moder-ate*	*Exten-sive*
Rationale for Teaching Course	58	42	47	53	50	28	20	2
Sequence and Timing of Objectives	92	8	91	9	13	31	45	12
Language Across the Curriculum	49	51	40	60	52	35	14	0
Equity (sex) and Multiculturalism	43	57	36	64	55	32	13	0
Modifications for Exceptional Students	56	44	50	51	50	33	16	1
Career Awareness	71	29	64	36	31	32	33	5
Canadian Science and Scientists	46	54	43	57	51	31	15	3
Laboratory Activities	90	10	86	14	14	29	51	7
Safety	78	22	69	31	36	29	30	6
Teaching Strategies	90	10	85	15	16	34	46	4
Mode of Delivery	76	25	71	29	27	39	33	2
Resources - texts, other print materials, lab equipment	87	13	78	22	22	31	30	18
Student Assessment Strategies	88	12	82	18	18	43	36	3
Other	3	97	3	97	98	1	0	1

12. Standard Errors Associated with the Student Achievement Results Presented in this Report

Since multiple-matrix sampling was used to collect student achievement data, each question as well as each set of questions were answered by one fifth of the students. The results from these samples of students are assumed to represent the achievement levels that would have been obtained had all students attempted all questions.

There is some error of measurement associated with this approach and Display 67 presents the standard errors of measurement associated with the provincial sample's student achievement results. Confidence intervals of at least plus/minus one standard error should be consrtucted around the levels of student achievement seen in the provincial sample. These intervals

Display 66
Average Levels of Reported Current and Desired Influence of Principals and Department Heads Upon the Curriculum Management Process as Reported by Department Heads
Provincial Results - Physics

Stages of Curriculum Management Process	*Degree of Influence*			
	Department Head		*Principal*	
	Current	*Desired*	*Current*	*Desired*
Determining the Need for a Review of the Course	2.4	2.6	1.6	1.7
Reviewing Components of the Course	2.3	2.5	1.3	1.5
Developing or Revising Components of the Course	2.2	2.4	1.2	1.3
Implementing New or Revised Components of the Course	2.4	2.5	1.3	1.5

Degree of Influence: 1 - None 2 - Some 3 - Much

identify the possible range of the provincial sample's achievement scores had all students attempted all questions. The accompanying document *Guidelines for Determining the Accuracy of Student Achievement Scores* provides further details concerning the meaning of standard errors.

13. Summary of Displays

Display 68 provides a summary of the tables, graphs and charts reported at the three levels of the review: school, board and province.

Display 67
Standard Errors Associated with the Student Achievement Results for this School
English – Physics

Student Achievement Statistic	*Standard Error*
For a question with 10% correct responses	0.8
For a question with 20% correct responses	1.1
For a question with 30% correct responses	1.2
For a question with 40% correct responses	1.3
For a question with 50% correct responses	1.4
For a question with 60% correct responses	1.3
For a question with 70% correct responses	1.2
For a question with 80% correct responses	1.1
For a question with 90% correct responses	0.8
For the average on content domain 1	0.2
For the average on content domain 2	0.3
For the average on content domain 3	0.3
For the average on content domain 4	0.3
For the average on content domain 5	0.2
For the average on content domain 6	0.3
For the average on process domain 1	0.2
For the average on process domain 2	0.2
For the average on process domain 3	0.2

Based on matrix sampling of 6794 students.

Display 68
Summary Guide of Displays for the Senior Division Physics Provincial Review Found in the Provincial, Board and School Results

P = Provincial Results
B = Board Results
S = School Results

PBS	*Display 1.* Participation Rates
PB	*Display 2.* Percentage of Teachers with Varying Years of Teaching Experience and Experience Teaching Advanced Level Science
PB	*Display 3.* Teachers' Reports of Their Educational Background and Special Qualifications
PB	*Display 4.* Percentage of Teachers Using Various Methods for Keeping Knowledge Up-To-Date
PB	*Display 5.* Percentage of Classes Reported Taught at Varying Class Enrollments
PBS	*Display 6.* Percentage Gender Enrollment in the Senior Division Science Course
PBS	*Display 7.* Student Reports of Future Educational Plans and Whether Science Courses are Expected in These Future Plans
PBS	*Display 8.* Percentage of Students Reporting Use of a Computer for Various Activities at Home and Hours of Use of a Computer at School Per Week
PB	*Display 9.* Student Reports of Frequency of Various Classroom Activities on the Parts of Their Teachers
PBS	*Display 10.* Student Reports of Number of Hours Spent Per Week on Homework in Science and Homework in All Subject Areas
PBS	*Display 11.* Percentage of Students Reporting Varying Amounts of Television Watching and Reading Each Day
PBS	*Display 12.* Percentage of Students Reporting Various Employment Activities and Number of Hours Spent Per Week Working
PBS	*Display 13.* Percentage of Students Reporting Various Out-of-School

Activities Concerned With Science

PBS *Display 14.* Percentage of Students Reporting Various Levels of Involvement in School Science Fairs

P *Display 15.* Analysis of the Courses of Study: Percentage of Schools Containing Various Components

PB *Display 16.* Percentage of Teachers Reporting Inclusion of Various Components in their School's Courses of Study and the Amount of Influence of these Components On Their Teaching

PB *Display 17.* Percentage of Teachers Reporting Varying Number of Hours Spent on Topics

P *Display 18.* Box and Whiskers Chart Indicating Variation Among Schools in Average Time Spent on Various Topics

PB *Display 19.* Teachers' Average Report of Percentage of Class Time Spent in Various Instructional Activities

PBS *Display 20.* Percentage of Students Reported by Teachers as Having Had the Opportunity-to-Learn the Science Necessary to Answer the Questions Correctly by Process Level

PBS *Display 21.* Percentage of Students Reported by Teachers as Having Had the Opportunity-to-Learn the Science Necessary to Answer the Questions Correctly by Content Domain

PBS *Display 22.* Percentage of Students Reported by Teachers as Having Had the Opportunity-to-Learn the Science Necessary to Answer the Questions Correctly by Process Level and Content Domain

PB *Display 23.* Percentage of Teachers Indicating Whether the Science Necessary to Answer Each Question Had Been Taught or Reviewed, and If Not, the Reasons For Not Teaching or Reviewing the Science

P *Display 24.* Box and Whiskers Chart Indicating Variation Among Schools in Average Student Opportunity-To-Learn: Questions Grouped by Process Level

P *Display 25.* Box and Whiskers Chart Indicating Variation Among Schools in Average Student Opportunity-To-Learn: Questions Grouped by Content Domain

PB *Display 26.* Percentage of Teachers Reporting Varying Frequency of Use of Teaching Resources

PB *Display 27.* Percentage of Teachers Reporting Varying Frequency of Use of Teaching Approaches

PB *Display 28.* Percentage of Teachers Reporting Varying Frequency of Evaluation for Diagnostic, Formative, and Summative Purposes

PB	*Display 29.* Percentage of Teachers Reporting Varying Emphasis upon Norm-Referenced, Criterion-Referenced, Individualized Ability, and Growth-Based Approaches to Evaluation
PB	*Display 30.* Percentage of Teachers Reporting Varying Frequency of Use of Various Evaluation Methods
PB	*Display 31.* Proportional Weights Assigned to Various Evaluation Practices by Teachers for Assigning Students' Final Grades
PB	*Display 32.* Percentage of Teachers Reporting Varying Student Classroom Use of Calculators and Computers
PB	*Display 33.* Percentage of Teachers Reporting Varying Amounts of Homework Assigned Each Week
PB	*Display 34.* Percentage of Teachers Reporting Varying Frequency of Student Activities During the Course Concerned With Experimental Method
PB	*Display 35.* Percentage of Teachers Reporting Varying Frequency of Instruction Focussed Upon the Experimental Method
PB	*Display 36.* Percentage of Teachers Placing Varying Levels of Importance Upon Various Learning Objectives Concerned With Experimental Method
PB	*Display 37.* Percentage of Teachers Reporting Use of Various Strategies for Teaching the Concept of Work
PB	*Display 38.* Percentage of Teachers Reporting Use of Various Evaluation Techniques for Assessing Student Learning of the Concept of Work
PB	*Display 39.* Percentage of Teachers Reporting Student Access to Computers in the School and in the Classroom
PB	*Display 40.* Percentage of Teachers Reporting Varying Use of Computer Programs in the Classroom
PB	*Display 41.* Percentage of Teachers Reporting the Availability and Amount of Use of Various Ontario Educational Software Service Programs
PB	*Display 42.* Percentage of Teachers Reporting Various Sources of Their Training in Instructional Use of Computers and Hours Received in Such Training
P	*Display 43.* Box and Whiskers Chart of Teacher Reports of the Percentage of Time That Would Be Appropriate for Classroom Use of Computers if the Appropriate Software was Available
PBS	*Display 44.* Percentage of Students Answering the Questions Correctly by Process Level

PBS	*Display 45.* Percentage of Students Answering the Questions Correctly by Content Domain
PBS	*Display 46.* Percentage of Students Answering the Questions Correctly by Process Level and Content Domain
P	*Display 47.* Box and Whiskers Chart Indicating Variation Among Schools in Average Student Achievement: Questions Grouped by Process Level
P	*Display 48.* Box and Whiskers Chart Indicating Variation Among Schools in Average Student Achievement: Questions Grouped by Content Domain
PBS	*Display 49.* Detailed Item Analysis for Student Achievement Questions
PS	*Display 50.* Percentage of Student Responses Falling Within Various Response Categories for the Components of the Extended Response Achievement Questions by Content Domain and Process Level
P	*Display 51.* Interpretation Panel Ratings of Student Achievement by Content Domain and Process Level
P	*Display 52.* Interpretation Panel Ratings of Student Achievement by Individual Question Together with Summary Question Data
PBS	*Display 53.* Percentage of Students Providing Various Response Options for the Attitude Scales Items
PBS	*Display 54.* Percentage of Students Indicating Positive, Neutral and Negative Attitudes Towards Science on the Various Attitude Scales
P	*Display 55.* Box and Whiskers Chart Indicating Variation Among Schools in Average Student Attitudes Towards Science
PB	*Display 56.* The Review Process: Percentage of Schools Reporting The Occurrence of Their Most Recent Course Review
PB	*Display 57.* The Review Process: Percentage of Schools Reporting Procedure by Which Most Recent Course Review Was Conducted
PB	*Display 58.* The Review Process: Percentage of Schools Reporting The Single Most Important Reason for Most Recent Course Review
PB	*Display 59.* The Review Process: Percentage of Schools Reporting The Level of Influence Exerted By Various Sources On the Initiation of the Course Review
PB	*Display 60.* The Review Process: Percentage of Schools Reporting Varying Levels of Use of Resources in the Review

PB	*Display 61.* The Development Process: Percentage of Schools Reporting Process by Which Most Recent Development Was Undertaken
PB	*Display 62.* The Development Process: Percentage of Schools Reporting The Level of Involvement of Various Sources With Recent Course Development
PB	*Display 63.* The Development Process: Percentage of Schools Reporting Varying Levels of Use of Resources in Recent Course Development
PB	*Display 64.* The Implementation Process: Percentage of Schools Rating Various Factors as Either Positive, Negative, or Neutral Influences in the Implementation of Course Changes
PB	*Display 65.* Summary of Review, Development, and Implementation Practices: Percentage of Schools Reporting Various Course Components Influenced by the Curriculum Management Process
P	*Display 66.* Average Levels of Current and Desired Influence of Principals and Department Heads Upon the Curriculum Management Process as Reported by Department Heads
PBS	*Display 67.* Standard Errors Associated with the Student Achievement Results Presented in These Results
PBS	*Display 68.* Summary Guide of Displays for the Senior Division Physics Provincial Review

14. LINKAGES

Correlation of Teacher Reports of Coverage and Student Achievement

The large scale assessment literature indicates that when students are given the opportunity-to-learn the content and skills asociated with the assessment instruments, this is usually the single best predictor of student achievement. In the case of the present review this also proved to be the case.

Display 69 presents the correlations of teachers' reports of student opportunity-to-learn (taught, reviewed, or assumed taught prior) with student achievement on the objective questions. The data is classified by the three process levels and six content areas used throughout this review.

The bars on the graph represent the degree of association for the provincial sample of physics classes between teacher reports of higher coverage and higher student achievement on the questions. The graph does not indicate anything about the absolute level of coverage or achievement (see Displays 20-25 for data concerning opportunity-to-learn and Displays 44-48 for student achievement results), but rather the relationship between reports of coverage and student achievement.

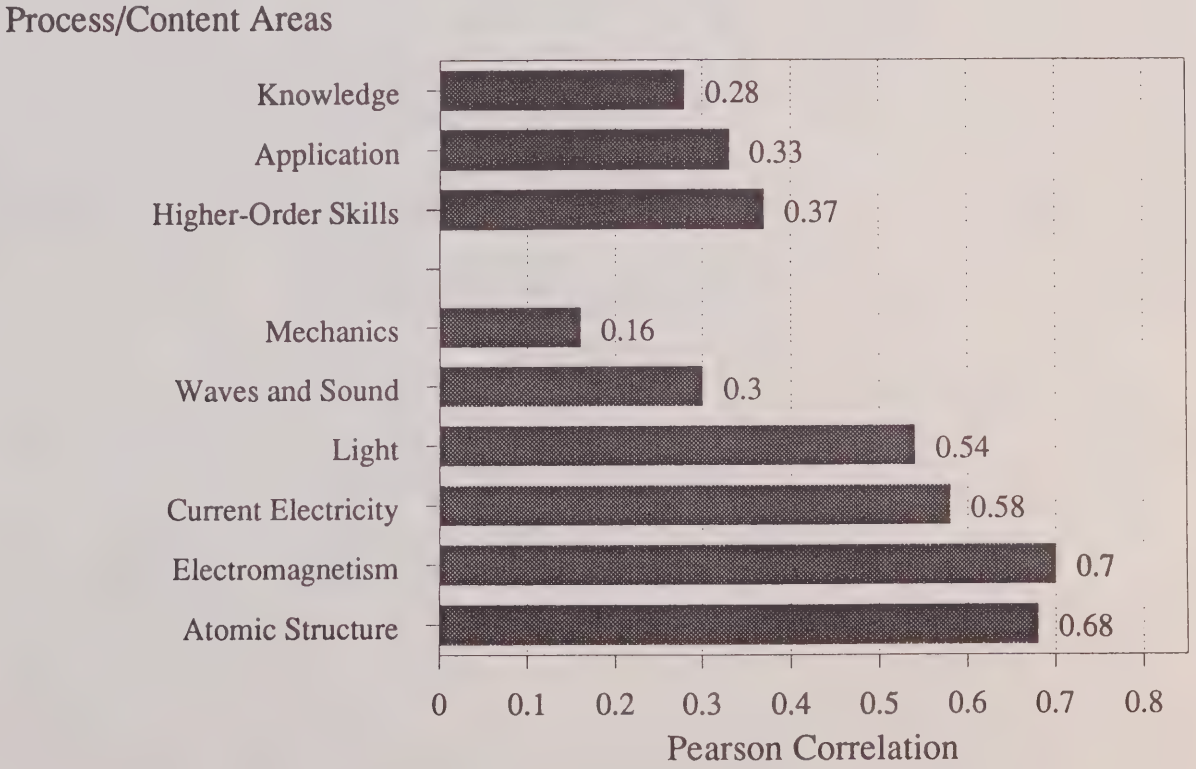
As shown in Display 69, all the correlations were both statistically and practically significant. **The correlation coefficient squared indicates the amount of variation in student achievement accounted for by coverage.** For example, more than 10% ($.37^2$) of the variation in student achievement in the Higher-order Skills questions could be accounted for by teachers' coverage of these questions.

For the Atomic Structure and Electromagnetism content areas almost 50% of the variation among classes in student achievement could be accounted for by differences in teachers' reports of coverage of the material assessed by these questions. Similarly, high correlations were observed in all the content areas except Mechanics where a rather small association was seen between achievement and opportunity-to-learn.

Congruence of Teachers' Predictions with Levels of Student Achievement Achievement

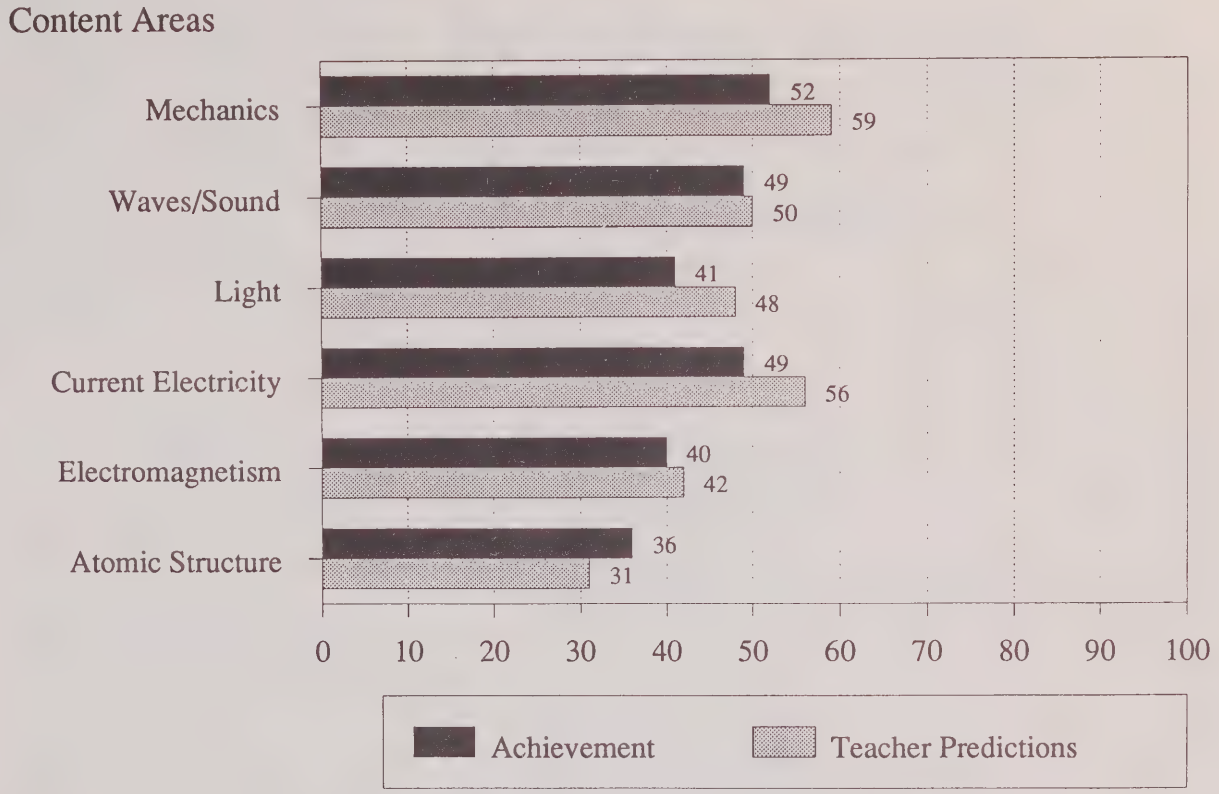
Display 70 presents the levels of actual attained student achievement in the six content areas and teachers' predicted levels. Teachers tended to overestimate students' achievement levels for all areas except Atomic Structure. For the questions concerned with the Mechanics and Current Electricity content areas, teachers overestimated by about 7 percentage points and less so for other areas.

Display 69: Magnitude of Association Between Teachers' Reports of Coverage and Student Achievement



Physics Provincial Review

Display 70: Congruence Between Teachers' Predictions and Student Achievement



Physics Provincial Review

ENDNOTES

[1] Ontario Ministry of Education(1988). *Curriculum Management Resource Guide.* Toronto: Queen's Printer for Ontario.

[2] The study is described in a three-volume Background Study of the Science Council of Canada, *Science Education in Canadian Schools.* Conclusions and recommendations are contained in: *Science for Every Student: Educating Canadians for Tomorrow's World. Report 36* (1984)

[3] The SISS study is perhaps best described in two documents:

(i) Connelly, F.M., Crocker, R.K. and Kass, H. (Eds)(1985) *Science Education in Canada: Vol 1 - Policies, Practices and Perceptions.* Toronto: Ontario Institute for Studies in Education.

(ii) Connelly, F.M. (1987). *Ontario Science Education Report Card: Canadian National Comparisons.* Toronto: Queen's Printer for Ontario.

[4] Ibid. note 3.

[5] Science Teachers' Association of Ontario (1985). *A Rationale for Quality Science Education in the Schools of Ontario.* Kingston: STAO Resource Centre, Queen's University.

[6] Extensive reports of the field trials of the Chemistry Pool are found in two documents, released in 1987. As well as field testing the OAIP instruments, many questions were asked of teachers and students regarding the teaching and learning of Chemistry in Ontario.

(i) McLean, L.D. (1987). *Teaching and Learning Chemistry in Ontario in the Senior Division.* Toronto: Ontario Ministry of Education

(ii) Talesnick, I., and McLean, L.D. (1987) Report of the 1983 Field Trials in Chemistry - Senior Division. Toronto: Ontario Ministry of Education.

[7] For a complete description of the new Intermediate/Senior science program, see Part I of the guideline: *Science: Intermediate and Senior Divisions (1987). Part I Program Outline and Policy.* The entire guideline consists of 15 parts covering all science courses offered from Grade 7 to OAC at three levels of difficulty.

[8] The Primary/Junior science program is described in *Science Is Happening Here - A Policy Statement for Science in the Primary and Junior Divisions.* (1988) Toronto: Ontario Ministry of Education. This new policy is based upon the Statement of Direction released by the Ministry in 1986 - Science in Primary and Junior Education - A Statement of Direction.

[9] The SIMS design is described in: McLean, L.D., Raphael, D., and Wahlstrom, M.W. (1985). *Intentions and Attainments in the Teaching and Learning of Mathematics: Report on the Second International Mathematics Study in Ontario.* Toronto: Ontario Ministry of Education.

A more detailed description of the background to the Ontario process is found in a paper presented at the ECS/CDE Conference on Assessment and Curriculum Reform, Boulder, CO., June, 1988.

Raphael, D., Morrow, R., and others. (1988). *A Curriculum Based Approach to Assessment: Provincial Reviews in Ontario.* Toronto: Ontario Ministry of Education, Program Implementation and Review Branch.

[10] The relationship between the thirteen goals of Education for Ontario, and the aims of science education, in terms of Curriculum Emphases, is found in Part I of the Intermediate Senior Science Guideline, Section 3.4.

[11] Roberts, D. (1982). Developing the Concept of "Curriculum Emphasis" in Science Education. *Science Education*, 66.2, p.245.

[12] McLean, (1987) op.cit.

Physics

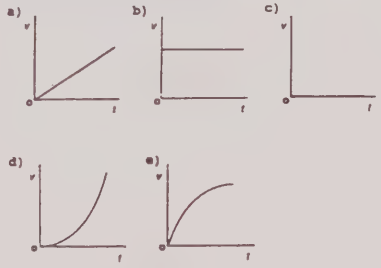
Advanced Level
Senior Division

Student Assessment Booklet

PROVINCIAL REVIEWS

CHEMISTRY AND PHYSICS

1. A cart, initially at rest, is pulled with a constant, unbalanced force. Which speed-time graph best represents the motion of the cart?



2. Suppose that the only forces acting on a 12 kg mass are those shown in the diagram.

The acceleration of the mass shown is:

a) 0.5 m/s^2 [W]

b) 2.0 m/s^2 [W]

c) 5.0 m/s^2 [W]

d) 8.0 m/s^2 [W]

e) 24 m/s^2 [W]

3. Work is always done when

a) an object has potential energy.

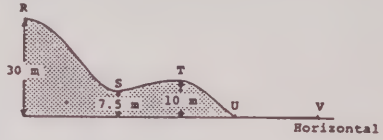
b) an object is moving on a frictionless surface.

c) a force is applied perpendicular to the direction an object moves.

d) an object moves in the direction of the force.

e) a force is exerted on an object.

4. A cross section of a frictionless downhill ski run shows the vertical height above the horizontal for various locations. A skier whose mass is 75 kg starts downhill at R. ($g = 10$ m/s^2)



What is the kinetic energy of the skier at T?

a) 8.0×10^2 J

b) 1.5×10^3 J

c) 7.5×10^3 J

d) 8.0×10^3 J

e) 1.5×10^4 J

5. The following diagram shows different points labelled on a wave.

Which one of the labelled points is in the same phase as point X?

a) A

b) B

c) C

d) D

e) none of these

6. The diagrams below represent four different standing wave patterns in air columns of equal length.

Which of the columns will produce the sound having the longest wave length?

a) I

b) II

c) III

d) IV

e) All columns are producing sound of the same wavelength.

7. When a light ray travels at an oblique angle from a medium with a lower refractive index (such as air) into a medium with a higher refractive index (such as glass), it

a) bends towards the normal.

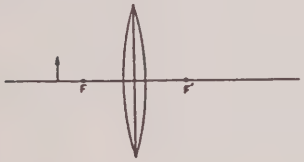
b) bends to travel along the normal.

c) bends away from the normal.

d) doesn't bend at all.

e) reflects straight back.

8. An object is placed near a convex (converging) lens as shown below.



What is the correct description of the image?

a) larger, upright, virtual

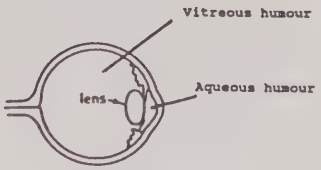
b) smaller, upright, virtual

c) smaller, inverted, real

d) larger, inverted, real

e) same size, inverted, real

9.



The lens in the human eye is surrounded by clear fluids (aqueous and vitreous humour). The refractive index of these fluids is

a) equal to 1.

b) slightly less than 1.

c) greater than 1, but less than the refractive index of the lens material.

d) greater than the refractive index of the lens material.

e) equal to the refractive index of the lens material.

10. Resistances of 2.0 Ω , 4.0 Ω and 6.0 Ω are connected in series with a 24 V battery. The current flowing through the circuit is

a) 12 A

b) 4.0 A

c) 2.4 A

d) 2.0 A

e) 0.50 A

11. A current of 0.50 A flows through a potential difference of 100 V. What is the resistance of the circuit in ohms?

a) 5.0×10^{-3} Ω

b) 2.5×10^{1} Ω

c) 5.0×10^{1} Ω

d) 2.0×10^{2} Ω

e) 4.0×10^{2} Ω

12. Twelve 1.5 V dry cells connected in parallel will produce a total voltage of

a) 1.5 V

b) 3.0 V

c) 8.0 V

d) 9.0 V

e) 18 V

13. This question involves two statements:

I. Alternating current is supplied to most households in Ontario.

II. The appliances of a household circuit are connected in parallel.

Which of the following responses correctly describes the two statements?

a) Both statements are true and one statement can be used to explain the other.

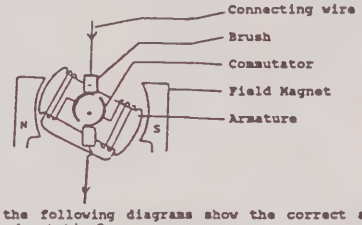
b) Both statements are true, but neither statement can be used to explain the other.

c) Statement I is true.
Statement II is false.

d) Statement I is false.
Statement II is true.

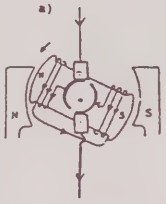
e) Statement I is false.
Statement II is false.

14. A simple DC motor is connected so that the electron flow is as shown in the diagram below.

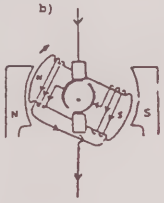


Which of the following diagrams show the correct armature polarity and rotation?

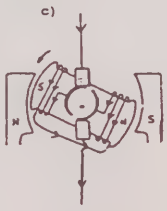
a)



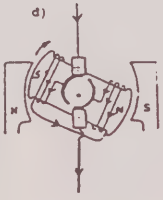
b)



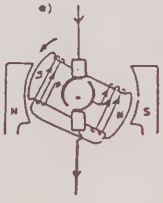
c)



d)



e)



15. A single straight conductor carries electrons out of the plane of the paper toward you as shown by the dot.

What direction and shape are the magnetic field lines with reference to the conductor?

a) clockwise concentric circles around the conductor

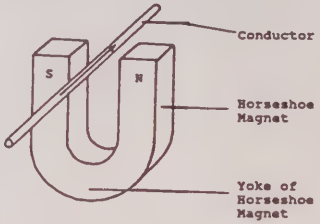
b) counter-clockwise concentric circles around the conductor

c) straight lines radiating outward from the conductor

d) straight lines radiating inward toward the conductor

e) straight lines directed from left to right on the page

16. As shown by the arrow in the diagram below, electrons flow through a copper conductor located between the poles of a horseshoe magnet.



If the conductor is free to move, it will be forced

a) toward the N pole of the magnet.

b) toward the S pole of the magnet.

c) upward away from both poles of the magnet.

d) downward toward the yoke of the magnet.

e) to rotate counterclockwise about its axis.

17. Consider the following factors for a magnet moving inside a coil:

I. the strength of the magnet

II. the number of turns in the coil

III. the speed at which the magnet moves

Which of the factors can affect the size of the voltage induced in the coil?

a) I only

b) II only

c) III only

d) I and II only

e) I, II and III

18. Which nucleus represents the missing term in the following nuclear fission reaction?

$$^{235}_{92}U \rightarrow ^{90}_{38}Sr + \_\_\_\_ + 3^{1}_{0}n + \text{Energy}$$

a) $^{143}_{54}Xe$

b) $^{143}_{56}Xe$

c) $^{143}_{55}Ba$

d) $^{93}_{51}Sb$

e) $^{143}_{51}Sb$

19. The main purpose of heavy water in the CANDU reactor is to

a) furnish neutrons for the fission process.

b) undergo fission and release energy.

c) decrease the speed of fast neutrons.

d) undergo fusion and release energy.

e) neutralize the fission products.

20. A gamma ray source and a Geiger counter are positioned on a laboratory bench. The Geiger counter reading is 300 counts per minute. A sheet of metal 6.00 mm thick is placed between the source and the counter. The reading on the counter is now 75.0 counts per minute.

If the thickness of the metal is reduced to 3.00 mm, the reading on the counter will be closest to

a) 75.0 counts per minute

b) 150 counts per minute

c) 300 counts per minute

d) 450 counts per minute

e) 600 counts per minute

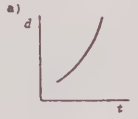
Physics

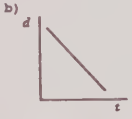
Advanced Level
Senior Division

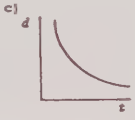
Student Assessment Booklet

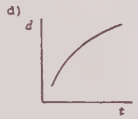
PROVINCIAL REVIEWS
CHEMISTRY AND PHYSICS
Ministry of Education, Ontario
Program Implementation and Review Branch

31. Which graph represents the motion of an object increasing in speed?

a) 

b) 

c) 

d) 

e)

32. A lead mass is suspended by a string held by your hand. The reaction to the force of gravity on the lead is the force exerted by

a) the string on the lead

b) the lead on the string

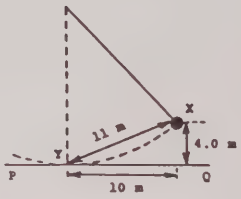
c) the hand on the string

d) the string on the hand

e) the lead on the earth

33. In the accompanying diagram, point X indicates the position of the bob of a long pendulum of mass 2.0 kg which has been pulled aside. (g = 10 N/kg)

The gravitational potential energy of the bob with respect to point Y is closest to



a) 8.0 J

b) 40 J

c) 80 J

d) 2.0×10^2 J

e) 2.2×10^2 J

34. Two waves X and Y travel in opposite directions in a medium. When interference takes place between X and Y

a) the speeds of X and Y change permanently.

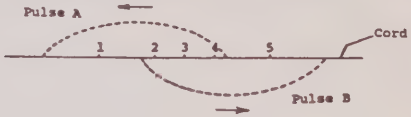
b) the shapes of X and Y change permanently.

c) the frequencies of X and Y change permanently.

d) the wavelengths of X and Y change permanently.

e) no permanent change takes place in X and Y.

35. Points 1, 2, 3, 4, and 5 are marked on a stretched cord. Pulses A and B, which have the same shape and size, are travelling through this cord at the same speed.



Which point(s) would have no motion, provided the pulses were moving in opposite directions?

a) points 1 and 2 only

b) points 2, 3, and 4 only

c) points 4 and 5 only

d) point 3 only

e) none of the above choices

36. The wave disturbance shown below is travelling from left to right through a medium.

What is the direction of the instantaneous velocity of a particle of the medium located at point V?

a) ↑

b) ↓

c) →

d) ↗

e) There is no direction since the velocity is zero.

37. If a wave train has a period of 2.00 s and a wavelength of 7.00 m, how far will it travel in 8.00 s?

a) 2.29 m

b) 17.0 m

c) 28.0 m

d) 56.0 m

e) 112 m

38. The image in a pinhole camera is always

a) virtual and inverted.

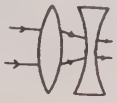
b) virtual and erect.

c) real and inverted.

d) real and erect.

e) smaller than the object.

39. Which of the diagrams below correctly illustrates the path of the light through the two lenses?

a) 

b)

c)

d)

e)

40. One volt is equivalent to

a) 1 W.s

b) 1 $\frac{J}{s}$

c) 1 $\frac{J}{C}$

d) 1 $\frac{s}{J}$

e) 1 $\frac{C}{J}$

41. An electric motor connected to a 100 V supply draws a current of 20 A. If electricity costs six cents per kilowatt hour, the cost of running the motor for 8.0 h is

a) 96¢

b) 64¢

c) 48¢

d) 24¢

e) 1.5¢

42. A total resistance of 3.0 Ω is to be produced by connecting an unknown resistance to a 12 Ω resistance.

What must be the value of the unknown resistance and how should it be connected?

a) 3.0 Ω in parallel

b) 3.0 Ω in series

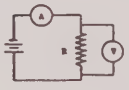
c) 4.0 Ω in parallel

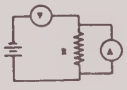
d) 4.0 Ω in series

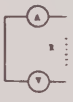
e) 6.0 Ω in parallel

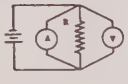
43. In the following circuits an ammeter (A), a voltmeter (V), a resistor (R) and a battery are shown. It is desired to measure the current passing through the resistor and the potential difference across it.

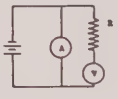
In which one of the following circuits are the instruments connected correctly?

a) 

b) 

c) 

d) 

e) 

44. Consider the following changes made to an electromagnet:

I. increasing the number of turns in the coil

II. using a copper core instead of an iron core

III. decreasing the current flow in the coil

The strength of the electromagnet is increased by:

a) I only

b) II only

c) III only

d) I and II only

e) I, II and III

45. The reason that some materials are more easily magnetized than others is that

a) their molecules are already arranged in magnetic domains.

b) they have a greater number of magnetic domains.

c) there are more magnetic domains spinning in one direction than in the opposite direction.

d) their magnetic domains are more easily lined up in the same direction.

e) they have stronger magnetic domains.

46. The diagram illustrates a straight wire conductor situated between the poles of a permanent magnet. The poles of the magnet are in the plane of the page, and the wire is perpendicular to the plane of the page. The wire is carrying an electron flow away from you into the plane of the page as indicated by the cross.

The direction of the magnetic force on the wire is

a) ↑

b) ↓

c) ←

d) →

e) the same as the electron flow.

47. This question involves two statements:

I. An electric current can be increased by means of a step-up transformer.

II. In a step-up transformer the output power is greater than the input power.

Which of the following responses correctly describes the two statements?

a) Both statements are true and one statement can be used to explain the other.

b) Both statements are true, but neither statement can be used to explain the other.

c) Statement I is true.
Statement II is false.

d) Statement I is false.
Statement II is true.

e) Statement I is false.
Statement II is false.

48. The element manganese has an atomic number of 25 and a mass number of 55. Its nuclei consist of

a) 25 protons and 25 neutrons.

b) 25 protons and 30 neutrons.

c) 25 protons and 55 neutrons.

d) 30 protons and 25 neutrons.

e) 55 protons and 25 neutrons.

49. If $^{225}_{88}Ra$ gives off a negative beta particle, the remaining nucleus is

a) $^{225}_{89}Ac$

b) $^{224}_{89}Ac$

c) $^{225}_{88}Ra$

d) $^{225}_{87}Fr$

e) $^{224}_{87}Fr$

50. X rays have

a) a negative charge.

b) a positive charge.

c) no charge.

d) the same charge as a beta ray.

e) the same charge as a helium nucleus.

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61. Which one of the following is a unit of power?

a) joule

b) kilowatt

c) kilowatt hour

d) newton

e) joule second

62. A baseball of mass 0.200 kg has a speed of 31.0 m/s. Its kinetic energy is

a) 3.10 J

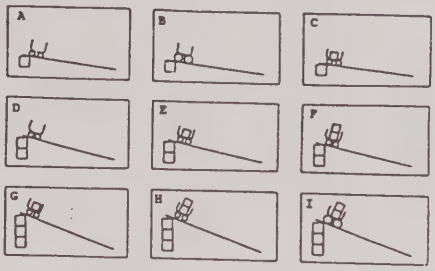
b) 6.20 J

c) 12.4 J

d) 96.1 J

e) 192 J

63. The diagrams below show different tests you can do with carts on ramps.



You want to test this idea: the heavier a cart and its load is, the greater its speed at the bottom of the ramp. Which three tests would you use?

a) A E H

b) D E F

c) C F I

d) G H I

e) A B C

64. A car starts from Hither, goes to Yon, and returns. The round trip distance of 100 km takes 2.00 h. The average speed for the round trip is:

a) 0

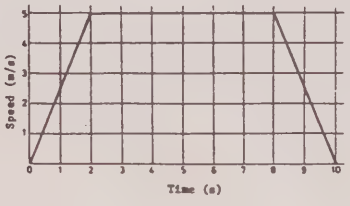
b) 0.0200 km/h

c) 50.0 km/h

d) 100 km/h

e) 200 km/h

65. An elevator moves from the basement to the tenth floor of a building. The mass of the elevator is 1000 kg and the elevator moves as shown in the speed-time graph below.



The acceleration of the elevator during the first two seconds of motion is

a) 10 m/s^2

b) 5.0 m/s^2

c) 2.5 m/s^2

d) 2.0 m/s^2

e) 0 m/s^2

66. This diagram shows two wave pulses approaching one another:

Which of the following diagrams best represents the appearance of the medium when the centres of the pulses coincide?

a)

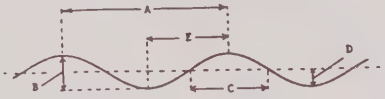
b)

c)

d)

e)

67. Consider the following wave diagram:



The wavelength of the wave is labelled correctly by the letter

a) A

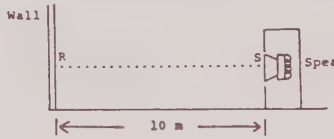
b) B

c) C

d) D

e) E

68. A stationary loud speaker sends sound waves of constant frequency along the line SR toward a solid wall 10 m away.



An observer, on moving from R toward S at constant speed, will hear sound of

a) constant frequency and intensity.

b) constant frequency and uniformly increasing intensity.

c) constant frequency and periodically changing intensity.

d) periodically changing frequency and intensity

e) periodically changing frequency and uniformly increasing intensity.

69. The phenomena of light bending as it passes from air into oil is described as

a) refraction.

b) diffraction.

c) interference.

d) specular reflection.

e) diffuse reflection.

70. Where must an object be placed with respect to a convex (converging) lens in order to obtain a virtual image?

a) at the principal focus

b) at twice the focal length

c) at a distance greater than twice the focal length

d) between the principal focus and the lens

e) between the principal focus and twice the focal length

71. Which instrument makes use of one double convex (converging) lens with the object located slightly inside the focal point?

a) camera

b) compound microscope

c) magnifying glass

d) overhead projector

e) telescope

72. A current of 0.80 A flows for 1.0 min. The total electric charge passing a point in this time is

a) 0.50 C

b) 1.3 C

c) 48 C

d) 75 C

e) 2.9×10^3 C

73. What is the effect when a second identical resistor is added in series in a circuit containing one resistor and a dry cell?

a) The resistance of the circuit decreases.

b) The resistance of the circuit increases.

c) The current through the original resistor stays the same.

d) The voltage drop across the original resistor stays the same.

e) The voltage drop across the original resistor increases.

74. If other factors remain constant, which of the following combinations of electric current and the number of turns in the coil produces the strongest electromagnet?

a) 500 turns and 3 A

b) 700 turns and 2 A

c) 300 turns and 4 A

d) 200 turns and 5 A

e) 100 turns and 10 A

75. A permanent magnet is held stationary in the centre of a coil connected to a galvanometer. The current reading on the galvanometer will

a) be steady and zero.

b) be steady and not zero.

c) steadily increase.

d) steadily decrease.

e) steadily increase and then decrease.

76. If M represents the change in magnetic field strength surrounding a conductor, which one of the following rates of change produces the greatest induced voltage?

a) 0.25 M in 0.5 s

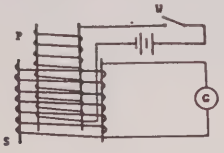
b) 0.5 M in 0.25 s

c) 1 M in 1 s

d) 3 M in 4 s

e) 100 M in 100 s

77. In the diagram below, the primary coil P is connected to a power supply and a switch W. The secondary coil S is connected to a galvanometer G. The primary coil is held stationary inside the secondary coil.



The following steps are performed:

I. The switch is closed to connect the circuit.

II. The switch is held closed.

III. The switch is opened to disconnect the circuit.

IV. The switch is held open.

During which of these steps does galvanometer G show a steady zero reading?

a) I only

b) II only

c) II and III only

d) II and IV only

e) I and III only

78. A beta particle is deflected more than an alpha particle by the same magnetic field because the beta particle

a) has a larger electric charge.

b) has a smaller electric charge.

c) has a larger mass.

d) has a smaller mass.

e) is moving more slowly.

79. The function of the control rods in a nuclear reactor is to

a) increase fission by slowing down the neutrons.

b) decrease the neutrons' energy without absorbing them.

c) increase the neutrons' ability to cause fission.

d) decrease fission by absorbing neutrons.

e) provide the critical mass for the fission reaction.

80. The nuclear reaction

$$^{239}_{94}Pu \longrightarrow {}^{139}_{54}Xe + {}^{94}_{38}Zr + 3\,{}^{1}_{0}n + \text{Energy}$$

is an example of

a) alpha decay

b) beta decay

c) gamma decay

d) nuclear fission

e) nuclear fusion

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91. An object moving at a constant velocity must

a) have a net force acting on it.

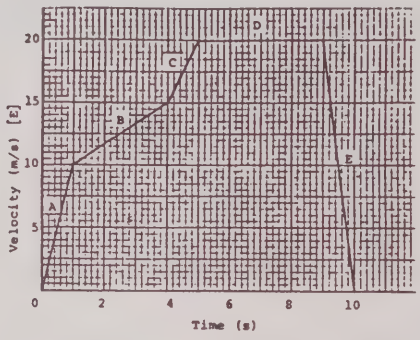
b) eventually stop due to the force of gravity.

c) not have any force of gravity acting on it.

d) have all forces that act on it balancing each other.

e) have no force of friction acting on it.

92. Shown below is the velocity-time graph for an object during a 10 s time interval.



Which segment of the graph shows the greatest average velocity?

a) A

b) B

c) C

d) D

e) E

93. What minimum work is required to lift a 14 kg mass a distance of 7.0 m? (g = 10 N/kg)

a) 9.8 J

b) 21 J

c) 98 W

d) 98 J

e) 9.8×10^2 J

94. A 50 W light bulb operating for 20 s uses the same amount of energy as a 100 W bulb operating for

a) 2.0 s

b) 5.0 s

c) 10 s

d) 20 s

e) 40 s

95. A pendulum makes 40 vibrations in 20 s. Its period is

a) 0.50 Hz

b) 0.50 s

c) 2.0 Hz

d) 2.0 s

e) 8.0×10^2 Hz

96. Vibrations are created at one end of a solid metal rod by touching the end with the stem of a vibrating tuning fork. After a time of 0.001 s the vibrations are detected at the other end.

If the metal rod is 1.0 m long and the tuning fork has a frequency of 200 Hz, the wavelength of the vibrations in the metal rod is most nearly

a) 0.2 m

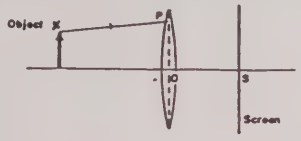
b) 0.5 m

c) 2 m

d) 5 m

e) 2×10^5 m

97. An object is located 30 cm from a convex (converging) lens as shown below. A sharp image forms on a screen when the screen is placed at S, 15 cm from the lens.



What happens to the ray XP after it is refracted by the lens?

a) It crosses the line OS between the optical centre and the principal focus.

b) It crosses the line OS between the principal focus and the screen.

c) It crosses the line OS extended at a point beyond S.

d) It emerges from the lens travelling parallel to the line OS.

e) It continues to diverge from the line OS.

98. The image of a candle produced by a concave (diverging) lens is always

a) virtual, on the same side of the lens as the object, and larger.

b) virtual, on the opposite side of the lens to the object, and larger.

c) virtual, on the opposite side of the lens to the object, and smaller.

d) real, on the same side of the lens as the object, and smaller.

e) virtual, on the same side of the lens as the object, and smaller.

99. The amount of light entering the eye is controlled by the

a) cornea

b) iris

c) lens

d) retina

e) optic nerve

100. A 6.00 V battery delivers 2.00 A for 1.00 min. The energy delivered is

a) 3.00 J

b) 12.0 J

c) 180 J

d) 720 J

e) 1.08×10^3 J

101. Current is a measure of

a) the force that moves a charge past a point.

b) the resistance to the movement of charge past a point.

c) the energy used to move a charge past a point.

d) the amount of charge that moves in a certain time past a point.

e) the speed that the charge moves past a point.

102. A 12 Ω resistor is connected in parallel with a 6.0 Ω resistor. The total resistance is

a) 18 Ω

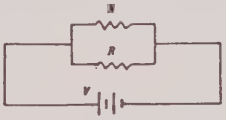
b) 12 Ω

c) 6.0 Ω

d) 4.0 Ω

e) 0.25 Ω

103. Two identical resistors are connected across a supply voltage V, as shown below.



The current flowing through each resistor is equal to

a) V/4R

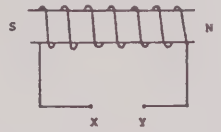
b) V/2R

c) 2V/R

d) V/R

e) R/V

104. The diagram shows the polarity of a coil connected to a battery. The terminals of the battery are indicated by X and Y.



On the basis of the information given, which one of the following conclusions is correct?

a) Electrons flow through the coil from end S to end N.

b) Y is the negative terminal of the battery.

c) There is no magnetic field outside the coil.

d) The coil is wound on a core material with high permeability.

e) The magnetic field lines inside the coil point from N to S.

105. Soft iron is used in the cores of lifting electromagnets rather than copper because iron

a) withstands a higher temperature.

b) has a greater resistance.

c) makes a better permanent magnet.

d) is a better insulator.

e) has a higher magnetic permeability.

106. A transformer has 500 turns in the primary coil and 6 000 turns in the secondary coil. If a current of 8.0 A flows in the primary coil, what current flows in the secondary coil?

a) 0.67 A

b) 1.5 A

c) 6.7 A

d) 96 A

e) 9.6×10^2 A

107. The diagram shows a wire in which there is a large electron flow from west to east. If a magnetic compass is held under and close to the wire, the N pole of the compass needle will point

a) south

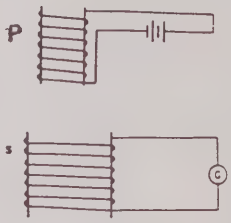
b) north

c) east

d) west

e) north east

108. The diagram represents a primary coil P, carrying a steady current, and a secondary coil S, which is connected to a galvanometer G.



The following steps are performed one after the other:

I. P is pushed rapidly into S

II. P is held stationary inside S

III. P is withdrawn rapidly from S

IV. P is held stationary outside S

During which of these steps does G show a steady zero reading?

a) I only

b) II only

c) II and III only

d) I and III only

e) II and IV only

109. Which of the following has the most penetrating power?

a) alpha particles

b) beta particles

c) cathode rays

d) gamma rays

e) X rays

110. This question involves two statements:

I. $^{238}_{92}U$ has the same atomic mass as $^{235}_{92}U$.

II. $^{238}_{92}U$ and $^{235}_{92}U$ are both isotopes of uranium.

Which of the following responses correctly describes the two statements?

a) Both statements are true and one statement can be used to explain the other.

b) Both statements are true, but neither statement can be used to explain the other.

c) Statement I is true.
Statement II is false.

d) Statement I is false.
Statement II is true.

e) Statement I is false.
Statement II is false.

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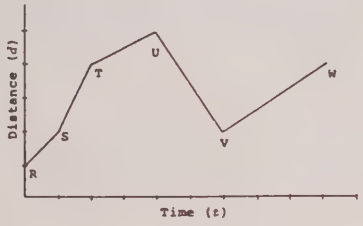
121. Consider the following graph.



The average speed is greatest during interval

a) RS
b) ST
c) TU
d) UV
e) VW

122. Action and reaction forces always occur in pairs. They do not cancel each other because

a) the action force is greater than the reaction force.
b) the action and reaction forces act on different objects.
c) the action and reaction forces act in the same direction.
d) the reaction force acts only after the action force is removed.
e) the reaction force is greater than the action force.

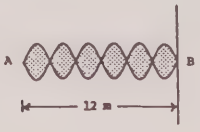
123. An object of mass 5.0 kg at the surface of the earth will have a force of gravity close to:

a) 0.50 N
b) 2.0 N
c) 5.0 N
d) 45 N
e) 50 N

124. A man pushed a stalled car with a 100 N force and moved it 0.50 m in 2.0 s. The power used by the man was

a) 2.5×10^1 W.
b) 5.0×10^1 W.
c) 1.0×10^2 W.
d) 4.0×10^2 W.
e) 5.0×10^2 W.

125. Waves generated at A are reflected at B to produce a standing wave as shown in the diagram.



The wavelength of the travelling waves which produce this standing wave pattern is

a) 2.0 m
b) 4.0 m
c) 6.0 m
d) 12 m
e) 36 m

126. A siren is located due west of your position. The sound is transmitted to your ear by

a) air vibrating in a north-south direction only.

b) air vibrating in a west-east direction only.

c) air vibrating in a vertical direction only.

d) air moving continuously westward only.

e) air vibrating in a vertical and west-east direction.

127. A sound wave has a wavelength of 3.0 m. The distance between the centre of a compression (condensation) and the centre of the adjacent rarefaction is

a) 0.75 m.

b) 1.5 m.

c) 3.0 m.

d) 6.0 m.

e) impossible to calculate without knowing the frequency.

128. Which diagram below best illustrates the path a light ray travels between the fixed points X in air and Y in glass?

a)

b)

c)

d)

e)

129. Where must a point light source be placed with reference to a convex lens to produce a ray of light leaving the lens which is parallel to the principal axis?

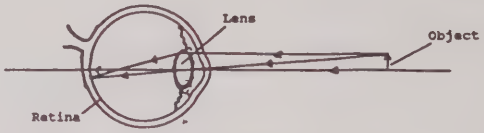
a) at a distance of two focal lengths from the lens

b) at the principal focus of the lens

c) between the principal focus and the surface of the lens

d) between the principal focus and a distance of two focal lengths from the lens

e) as far away as possible from the lens

130. 

What is the correct diagnosis for the vision demonstrated by the eye in the diagram above.

a) Astigmatism

b) Hypermetropic (farsightedness)

c) Presbyopic (lack of accommodation)

d) Normal

e) Myopic (nearsightedness)

131. An electric heater operating on a 100 V supply has a resistance of 20 Ω . The current in the heater is

a) 0.20 A

b) 5.0 A

c) 8.0×10^1 A

d) 1.2×10^2 A

e) 2.0×10^3 A

132. When a 12.0 V battery delivers 15.0 A of current, the power supplied is

a) 180 J.

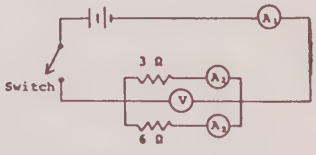
b) 180 W.

c) 1.25 W.

d) 0.800 J.

e) 0.800 W.

133. The diagram below shows a circuit containing a battery, a switch, three ammeters, a voltmeter, and two resistors.



When the switch is closed, the current through ammeter A_2 is

a) equal to the current through ammeter A_3.

b) twice the current through ammeter A_3.

c) half the current through ammeter A_3.

d) equal to the current through voltmeter V.

e) smaller than the current through voltmeter V.

134. A segment of a copper conductor is shown in the diagram. A compass is placed to the east of the conductor as shown. When electrons flow through the conductor, the N pole of the compass needle is deflected to point south.

The direction of the electron flow in the conductor is

a) east.

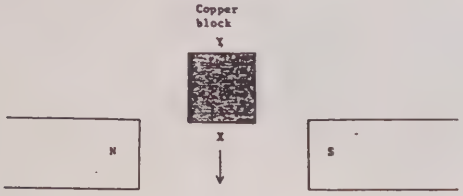
b) south.

c) west.

d) out of the plane of the page.

e) into the plane of the page.

135. Consider a copper block moving downward toward the region between two magnetic poles as shown below.



As the block enters in the magnetic field between the poles, electrons in the block will initially

a) shift towards you out of the plane of the page.

b) shift away from you into the plane of the page.

c) shift toward X.

d) shift toward Y.

e) remain where they were.

136. A generator supplies 100 V to the primary coil of a transformer with 50 turns. If the secondary coil has 500 turns, then the secondary voltage is

a) 1.0×10^3 V.

b) 5.0×10^2 V.

c) 2.5×10^2 V.

d) 1.0×10^2 V.

e) 1.0×10^1 V.

137. A step-down transformer is used to change

a) high power to low power.

b) direct current to alternating current.

c) alternating current to direct current.

d) high voltage to low voltage.

e) low voltage to high voltage.

138. Consider the following quantities:

I. mass number

II. energy

III. charge

During the process of radioactive decay, which of the above quantities will be conserved?

a) I only

b) II only

c) I and II only

d) II and III only

e) I and III only

139. If $^{221}_{88}Ra$ gives off an alpha particle, the remaining nucleus is

a) $^{221}_{89}Ac$

b) $^{221}_{88}Ra$

c) $^{217}_{86}Rn$

d) $^{221}_{86}Rn$

e) $^{217}_{84}Po$

140. The energy from nuclear fission results from

a) the fast moving fission fragments.

b) the disappearance of some mass during the fission process.

c) the extremely penetrative radiation given off.

d) the high speed of the neutrons.

e) the extreme heat in the reactor.

Physics

Advanced Level
Senior Division

Student Assessment Booklet

PROVINCIAL REVIEWS

CHEMISTRY AND PHYSICS

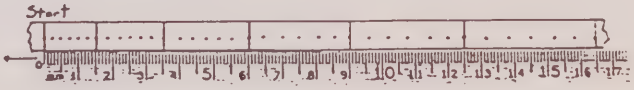
BOOKLET 1: PART D

INSTRUCTIONS:

On the special YELLOW answer sheet, indicate your name, the name of your school, school board, and teacher. Then provide a complete answer on the answer sheet in the places corresponding to the sections of the questions.

QUESTION:

The drawing below shows a paper tape that was pulled through a recording timer (a vibrator) by a toy car starting from rest. The timer vibrated 60 times per second leaving a black dot on the tape each time it made a vibration. A line was then drawn through every sixth dot.



(2.5 marks) a) How long did it take for the tape to pass through the timer?

(6.5 marks) b) After making the required measurements, complete the data table printed on the answer sheet so that it could be used to produce a position time graph for the motion of the car.

(5 marks) c) Describe the motion of the car using all three of the following terms: displacement (distance), velocity (speed), and acceleration.

Physics

Advanced Level
Senior Division

Student Assessment Booklet

BOOKLET 2: PART D

INSTRUCTIONS:

On the special *BLUE* answer sheet, indicate your name, the name of your school, school board, and teacher. Then provide a complete answer on the answer sheet in the places corresponding to the sections of the questions.

QUESTION:

(12 marks) a) For the position of the object shown on the answer sheet, locate and draw the image produced by the convex (converging) lens by drawing two appropriate rays.

(3 marks) b) State three characteristics of the image.

Physics

Advanced Level
Senior Division

Student Assessment Booklet

BOOKLET 3: PART D

INSTRUCTIONS:

On the special GREEN answer sheet, indicate your name, the name of your school, school board, and teacher. Then provide a complete answer on the answer sheet in the places corresponding to the sections of the questions.

QUESTION:

A ray of light is incident on the interface between air and a semi-cirular optical dish as shown on the answer sheet.

(2 marks) a) Measure and record the angle of the incidence.

(6 marks) b) Calculate the angle of refraction.

(4 marks) c) Accurately draw on the diagram the path taken by the refracted ray of light after it leaves the interface. Label the size of all relevant angles.

Physics

Advanced Level
Senior Division

Student Assessment Booklet

PROVINCIAL REVIEWS

CHEMISTRY AND PHYSICS

BOOKLET 4: PART D

INSTRUCTIONS:

On the special GOLD answer sheet, indicate your name, the name of your school, school board, and teacher. Then provide a complete answer on the answer sheet in the places corresponding to the sections of the questions.

QUESTION:

A 12 kg object initially at rest is acted upon by two forces at the same time. One force is 8.0 N [E]. The other force is 12 N [W].

(2 marks) a) Sketch a force diagram showing the horizontal forces acting on the object.

(4 marks) b) Find the net force acting on the object.

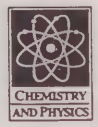
(3 marks) c) Calculate the acceleration of the object.

(3 marks) d) Determine the velocity of the object after 26s.

Physics

Advanced Level
Senior Division

Student Assessment Booklet



BOOKLET 5: PART D

INSTRUCTIONS:

On the special PINK answer sheet, indicate your name, the name of your school, school board, and teacher. Then provide a complete answer on the answer sheet in the places corresponding to the sections of the questions.

QUESTION:

(5 marks) a) List the sequence of key steps a scientist takes when solving a problem which involves an experiment. This sequence of steps is normally called the scientific method.

(7 marks) b) Imagine that you have been hired by a company that manufactures light bulbs to test a new material to be used in making lightbulb filaments.

The company has asked you to determine how the lifetime of a new filament is related to the electrical potential difference applied across the filament.

By referring to each step of the scientific method you identified in part (a), describe an experiment you would perform to solve the problem posed by the company. Pay particular attention to the control of variables.

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